THREE ESSAYS ON MULTIREGIONAL APPLIED GENERAL EQUILIBRIUM MODELLING

By

Ana María Iregui

Thesis submitted for the degree of
Doctor of Philosophy
to the

University of Warwick
Department of Economics

September 1999

To my parents

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to several people, all of whom directly and indirectly contributed to the successful completion of this thesis. First of all I would like to thank my supervisors, Professor John Whalley and Dr. Jeffery Round, for the consistent support, guidance, and very insightful comments they provided in the preparation of this thesis.

I would like to thank Professor Michael Devereux, and Dr. Carlo Perroni for their valuable suggestions. I am also indebted to Lisandro Abrego and Keshab Bhattarai for their help. Constructive criticism was provided by participants of the Summer Warwick Workshop 1994. I would like to express my sincere appreciation to Patricia Camacho and María Teresa Ramírez for their generosity with some necessary data. Oscar Bautista, Fredy Cepeda and Ligia Melo from the Banco de la República also provided valuable help with important information. One colleague and friend who has provided intellectual encouragement and invaluable help with GAMS is Chris Dawkins. I thank her for this. Special thanks to Hazel Ashworth for her support and encouragement.

I wish to acknowledge the financial support from the Banco de la República. Without their financial support, this thesis would have hardly be finished.

Finally, to Jesús I have an eternal debt of gratitude for his love, encouragement, understanding, patience, editing abilities, and intellectual support during the last five years of graduate studies. My family in Colombia also have my gratitude for their moral support.

ABSTRACT

In this thesis three policy issues that are of particular relevance in the economic debate are analysed using multiregional CGE models. The first of these issues is related to the welfare effects of the decentralised provision of quasi-private goods by the government. The second issue refers to the exportation of domestic taxes from developed to developing countries. And, the third issue is related to the efficiency gains from the elimination of global restrictions on international labour mobility. Two types of multiregional CGE models can be distinguished. The first type of models disaggregates the national economy into regions, whereas in the second type, regions consist of countries or groups of countries. In this thesis both types of models are used.

Chapter 2 quantifies the welfare effects of decentralisation in Colombia, using a multiregional CGE model. The purpose of this chapter is to investigate to what extent will the Colombian population be better off when goods such as health and education, are delivered locally as against centrally. A provision scheme based on the median voter is considered. Neither multiregional CGE models nor schemes for public provision of quasi-private goods have been previously applied when assessing the effects of decentralisation. According to the results, the provision of health and education by regional governments improves the welfare of the Colombian population as a whole, since regional governments provide goods and services in a way that better caters to local preferences. More importantly, these welfare gains vary from 1.3% to 2.3% of GDP, a substantial magnitude especially when compared with the efficiency gains associated to the tax reforms of the early nineties.

Chapter 3 investigates whether developed countries export taxes to developing countries, contributing to the deterioration of their terms of trade and welfare; that is to what extent the distribution of gains from trade is being affected not by existing tariffs in developed countries, which are already at low levels, but by their domestic taxation. An eight-region CGE model for the world economy is used. The results indicate that when factors of production are internationally immobile, developed regions do not export domestic taxes to developing regions. On the contrary, when capital is assumed to be internationally mobile developed region export capital taxes to developing regions. Regardless of the assumptions on international capital mobility, the effects of import tariffs on welfare and terms of trade are larger than those of domestic taxes.

Chapter 4 computes the world-wide efficiency gains from the elimination of global restrictions on labour mobility using an eight-region CGE model. A distinctive feature of the analysis is the introduction of a segmented labour market, as two types of labour are considered: skilled and unskilled. According to the results, when labour is a homogeneous factor, the elimination of global restrictions on labour mobility generates world-wide efficiency gains that could be of considerable magnitude. When the labour market is segmented and both skilled and unskilled labour migrate, welfare gains reduce since the benefits and losses of migration are not evenly distributed within each region. When only skilled labour migrates, the world-wide efficiency gains are smaller, since this type of labour represents a small fraction of the labour force in developing regions.

CHAPTER 1

INTRODUCTION

Since the early 1960s computable general equilibrium (CGE) models have been widely used by economists with the purpose of supporting the process of decision-making, especially when analysing public finances and foreign trade at the national level. At the regional level, it is only recently that these models have begun to be used for impact analysis. Throughout the years, economists have applied several modelling approaches in the area of regional economics. These include economic base methods, input-output analysis, gravity-type models, shift-share analysis, econometric models, and programming models.[1] These alternative approaches are not mutually exclusive, as they can be combined to produce new model types. For instance, in the construction of CGE models, analysts often rely on parameter estimates (such as elasticities) that have been previously estimated using econometric techniques.

In the early stages of regional modelling, analysts regarded regional models as an extension of modelling exercises at the national level. In this sense, models were typically developed for single regions (provinces, states, etc.) in order to assess the effects of national or regional policies at the regional level. The building blocks of these models typically assumed that the national economy was given, without allowing for any feedback influence. This approach of modelling constitutes a "top-

[1] For an introduction to these techniques see Glickman (1977), the collection of papers published in the Handbook of Regional and Urban Economics (Nijkamp, 1986), and Kraybill and Lugani (1992).

down" approach, since it specifies economic agents in a national model; the results from this national model are then "stepped down" to the regional level, using various regional-share assumptions (Kraybill and Lugani, 1992).

Early regional models mainly focussed on the evolution of a rather limited number of variables, such as the level of income, production, employment, tax revenues and public expenditure, since they were built using the structure of national models. Nijkamp et al (1986) indicate that these models suffer from a number of shortcomings including: a) the lack of horizontal (multiregional or interregional) feedback and spill-over effects; b) the lack of a satisfactory theoretical basis for including supply effects (e.g. the infrastructural components of a region); c) the lack of consistency of separate single region models with respect to the national total system; d) the lack of vertical feedback mechanisms between the national and the regional economies; e) the lack of specific orientation toward local, regional or national policy questions in various fields; and f) the lack of reliable data.

Trying to overcome these deficiencies, regional modelling has evolved in new directions during the last decades. In a first stage, between the late 1960s and the early 1970s, there was a development of regional models based on optimality concepts, followed by a strong trend towards econometrically specified regional models. During the 1970s, a second generation of regional models emerged, which incorporated supply constraints into the analysis, so that there were no longer infinite resources. From the mid-1970s onwards, a third generation of models emerged with a clear multiregional orientation, in which interactions among regions are represented.

In this thesis I analyse three policy issues that have become of particular relevance in the economic debate using multiregional CGE models. The first one is related to the welfare effects of the decentralised provision of quasi-private goods by

the government. The second one refers to the exportation of domestic taxes from developed to developing countries. And, the third one is related to the efficiency gains from the elimination of global restrictions on international labour mobility. A multiregional general equilibrium approach constitutes a suitable framework, because it deals explicitly with the interrelationships between different markets and different sectors of the economy. In addition, this approach is a suitable tool for analysing the effects of policy changes on resource allocation, the structure of distribution, and thus on economic welfare.

Two types of multiregional CGE models can be distinguished. The first type of models disaggregates the national economy into regions.[2] These models have been developed for countries such as the United States, Canada, and Australia (and more recently for Germany and India). They have been used to analyse public finance issues such as regional tax incidence (Kimbell and Harrison, 1984; Morgan et al, 1989; Mutti et al, 1989), spatial incidence of federal fiscal policies (Kraybill et al, 1992), tax exporting of regional taxes (Morgan et al, 1996), and whether the regions of a federal state should obtain the right to levy regional income taxes (Hirte, 1998). These models have been also used to analyse trade policy issues such as the impact of changes in federal trade policies on interregional trade (Jones et al, 1985), the effects of tax energy and inter-provincial trade policies (Jones and Whalley, 1988 and 1989), and the role of transportation costs in the evaluation of the effects of tariffs (Wigle, 1992).

Perhaps one of the major difficulties faced when dealing with these kind of multiregional CGE models is that of data availability. A benchmark data set involves the assembling of detailed production and demand accounts by regions, of

[2] See Kraybill and Lugani (1992) for a survey of this kind of models.

interregional and international trade flows, and of transactions involving multiple levels of government (St-Hilaire and Whalley, 1987). CGE data are assembled in a social accounting matrix (SAM), which is a system of balanced expenditure and income accounts.[3] Input-output tables are a very important part of a SAM, and the scarcity of multiregional input-output accounts imposes serious difficulties to multiregional CGE modelling. Indeed, only a few developed countries (i.e. Canada, Japan and Holland) prepare multiregional accounts on a regular basis.

In the second type of multiregional CGE models, regions consist of countries or groups of countries. This type of models have been used to analyse world trade (Whalley, 1985), the implications of trade protection on the North-South terms of trade (Whalley, 1984), the effects of trade liberalisation proposals (Nguyen and Wigle, 1992), the macroeconomic effects of migration flows from Eastern Europe and the former Soviet Union into the European Community (Weyerbrock, 1995), the effects of removing distortions in domestic factor taxes (taking into account international trade flows) (Whalley, 1980a), trade restricting impacts of tariffs and selected non-tariff barriers to world trade (Whalley, 1980b), and the North American Fee Trade Agreement – NAFTA (see the collection of papers in Francois and Shiells, 1994).

In this thesis both the subnational and supranational approaches to regional modelling mentioned above are used. In particular, Chapter 2 quantifies the welfare effects of decentralisation using a multiregional CGE model for Colombia, a country that began a rather ambitious process of state decentralisation in the late 1980s.[4]

---

[3] See Pyatt and Round (1985) for a discussion of the structure and use of SAMs, and Round (1986, 1988) for a presentation of several accounting approaches used in the construction of multiregional SAMs.

[4] According to World Bank (1994), this process has been slow and the pace of decentralisation among regions uneven.

Contemporaneously with the decentralisation effort, poverty reduction became an important issue in the government's agenda, and both decentralisation and poverty reduction were brought closer together with the introduction of the Law on local government functions and financing in 1993. The strategy to improve the standard of living of the population was primarily based on the provision of essential social services (such as health, education, housing and drinking water) and the generation of employment opportunities by shifting public expenditures towards social sectors. Regional governments were thus given the responsibility of delivering social programmes and services to the poor.

Chapter 2 examines to what extent will the Colombian population be better off when quasi-private goods and services, such as health and education, are delivered locally as against centrally. A quasi-private good is a good that has the characteristics of a private good, such as excludability and positive marginal costs of supply to an additional consumer, but is provided by the government. A provision scheme based on the median voter is considered. Neither multiregional CGE models nor schemes for public provision of quasi-private goods have been previously applied when assessing the effects of decentralisation.

According to the results, the provision of health and education by regional governments improves the welfare of the Colombian population as a whole, since regional governments provide goods and services in a way that better caters to local preferences. More importantly, these welfare gains vary from 1.3% to 2.3% of GDP, a substantial magnitude especially when compared with the efficiency gains associated to the tax reforms of the early nineties.

Chapter 3 investigates whether developed countries export taxes to developing countries, contributing to the deterioration of their terms of trade and

welfare. Trade negotiations have mainly concentrated on multilateral tariff reductions and in giving preferential treatment to developing countries, and hence helping them to improve their welfare. However, so far in the economic debate the role of domestic taxation in affecting the distribution of gains from trade, has been overlooked. Hence, the chapter investigates to what extent the distribution of gains from trade is being affected not by existing tariffs in developed countries, which are already at low levels, but by their domestic taxation.

The issue of tax exporting among countries has not been analysed empirically, although Mutti and Morgan (1986) and Morgan et al (1996) have looked at tax exporting among regions within the United States. One of the few analyses in this area is Whalley (1980a), who assesses the strength of relative price effects in international trade caused by the different domestic factor taxes which operate in the United States, the European Union, and Japan. Whalley uses a four-region general equilibrium model, which incorporates tariff, non-tariff and domestic taxation policies of major trading blocks, using data for 1973.

In this thesis tax exporting is investigated using a multiregional CGE model for the world economy. In this model there are eight regions: the United States (USA), the European Union (EU), Japan (JAP), other developed countries (ODC), developing America (DAM), developing Africa (DAF), developing Asia (DAS) and developing Europe (DE). Each region has a production and demand structure, and are linked through trade; the data are for 1990. With this regional classification is possible to consider from which region(s) developing sub-groups "import" taxes; this is an important issue, since developing regions have more commercial ties with one developed region than with others, and hence domestic tax policy in developed regions may affect one developing region more than another.

The results indicate that when factors of production are internationally immobile, USA, EU and ODC do not export domestic taxes to developing regions. However, the results suggest some degree of tax exporting from Japan JAP to the other regions, although the effects on both welfare and terms of trade are small. When capital is assumed to be internationally mobile, USA, JAP, EU, and ODC export capital taxes to developing regions. JAP exports labour and income taxes to developing regions, although the effects on welfare and terms of trade are small. Regardless of the assumptions on international capital mobility, the effects of import tariffs on welfare and terms of trade are larger than those of domestic taxes are.

Chapter 4 computes the world-wide efficiency gains from the elimination of global restrictions on labour mobility. This issue has been previously analysed by Hamilton and Whalley (1984) within a partial equilibrium framework. They assume that the world-wide labour supply is fixed, that full employment occurs in a world economy consisting of seven regions, and that differences in labour's marginal product across regions arise from barriers to inward mobility of labour in high wage countries.

I use a multiregional CGE model for the world economy (the regional classification is the same as in the previous chapter). A distinctive feature of the analysis is the introduction of a segmented labour market, as two types of labour are considered: skilled and unskilled. The segmentation of the labour market jointly with the general equilibrium framework allow us to examine the distributional effects of migration between skilled and unskilled labour in each region, and between these two and capital.

The results indicate that when labour is a homogeneous factor, the elimination of global restrictions on labour mobility generates world-wide efficiency

gains that could be of considerable magnitude. When the labour market is segmented and both skilled and unskilled labour migrate, welfare gains reduce since the benefits and losses of migration are not evenly distributed within each region. And, when only skilled labour migrates, the world-wide efficiency gains are smaller, since this type of labour represents a small fraction of the labour force in developing regions.

Finally, Chapter 5 presents a summary of the main conclusions of the thesis.

CHAPTER 2

DECENTRALISED PROVISION OF QUASI-PRIVATE GOODS: THE CASE OF COLOMBIA

2.1 INTRODUCTION

The purpose of this chapter is to investigate to what extent will the Colombian population be better off when goods such as health and education, are delivered locally as against centrally. Health and education are quasi-private goods[1], that is goods that have the characteristics of private goods, such as excludability and positive marginal costs of supply to an additional consumer, but are publicly provided. In this case, public intervention could be justified on the grounds of market failure, merit wants, externalities, or distributional arguments (Hare, 1988).

Toward this end, I build a multiregional computable general equilibrium (CGE) model for Colombia in order to compare two provision scenarios: one in which the provision of the quasi-private goods is carried out centrally, against one in which provision is carried out regionally. The literature on the provision of private goods by the public sector is mainly normative, since it focuses on the characteristics of possible provision rules. In this modelling exercise, a provision rule based on the median voter is considered. In this framework, the median voter (either national or regional) determines the quantity of the publicly provided private good to be allocated to each consumer.

[1] The term quasi-private was taken from Boadway et al (1994).

During the last two decades the assignment of tax and spending powers between different levels of government has been receiving increasing attention from economists and policymakers alike. The main economic argument in favour of decentralisation is that it enhances economic efficiency, since regional governments tend to be better informed about local preferences than national governments.[2]

Many developing countries, including the transition economies of Eastern Europe, are turning to decentralisation as a way to escape from inefficient central governments, macroeconomic instability and inadequate economic growth (Bird, 1993). Decentralisation can also be justified on political grounds, especially if a country's population is not homogeneous in terms of ethnic, racial, cultural, linguistic, or other relevant characteristics are regionally distributed. In Canada, for example, the move towards greater decentralisation has been mainly the result of political considerations, as some provinces are demanding more independence. In China, greater decentralisation has been driven by the need to regain some control over national public revenue. And in Ethiopia, ethnic diversity together with the belief that decentralisation would help hold national unity have been behind the decentralisation effort (Tanzi, 1995).

In Colombia the centralist organisation of the government has been evident since the Political Constitution of 1886. Political, administrative and fiscal powers as well as the provision of public services were concentrated in the central government, leading to a growing dissatisfaction among the regions because of the lack of autonomy and deficiencies in the provision of public services. In the early eighties, a Commission on Intergovernmental Finances (Departamento Nacional de Planeación,

[2] See Boadway et al (1994) for a presentation of the pros and cons of decentralisation. For recent theoretical models of the costs and benefits of decentralisation see Lockwood (1998a, 1998b), and the references therein.

1981) recommended an increase in the use of local resources for local purposes, which in turn resulted in a new legislative framework for decentralising functions and finances. The Political Constitution of 1991 introduced some modifications to the prevailing territorial order of the country and redefined the functions of territorial entities, establishing new parameters to assign and determine transfers from the central government to lower levels of government. In 1993, each level of government was assigned functions in areas such as health, education, housing, drinking water and other public services.[3]

Contemporaneously with the decentralisation effort, poverty reduction became an important issue in Colombia. Poverty alleviation programs have been typically planned, executed and controlled by the central government. They are conceived as a multi-sectoral effort touching health, education, water, sanitation, utilities, family welfare, rural development and housing (World Bank, 1994). Given the observed decline in rural incomes and the prevailing level of violence in the country, the new strategy to improve the standard of living of the population was primarily based on the provision of essential social services (such as health, education, housing and drinking water), and the generation of employment opportunities by shifting public expenditures towards social sectors. Decentralisation and poverty reduction were then brought closer together with the introduction of the Law on local government functions and financing in 1993, which gave regional

[3] At the same time, a major change regarding the way transfers were allocated was introduced. Under the new regulations central government transfers were no longer allocated according to the population of each territorial entity, but based on unsatisfied basic needs, fiscal effort, administrative efficiency and, in some cases, in proportion to the potential population to be covered by health and education services. Also, the new regulations unified the source of the transfers so that they are now a growing percentage of the nation's current income.

governments the responsibility of delivering social programmes and services to the poor.[4]

The main contribution of this chapter relies on the fact that neither multiregional CGE models nor a scheme for public provision of private goods based on the median voter, have been previously applied to quantify the magnitude of the efficiency gains associated with decentralisation. This chapter develops an equilibrium structure in which the quantities of the quasi-private goods to be provided by the government, together with the taxes levied to finance their provision are endogenously determined. In addition, the provision of the quasi-private goods affects the production structure of the economy, since in some regions more (less) of the good is produced, so that factors of production reallocate both within and between regions. Hence, the multiregional CGE modelling approach constitutes an appropriate tool for this analysis, since it allows us to model the interrelationships between different regions.

According to the results which follow, the Colombian population as a whole is likely to be better off when the provision of health and education is carried out regionally as opposed to centrally, since with regional provision each consumer group is allocated an amount of the goods that is closer to its preferences. More importantly, these welfare gains vary between 1.3% and 2.3% of GDP approximately, a substantial magnitude especially when compared with the efficiency gains associated to the tax reforms of the early nineties.

The chapter is organised as follows. Section 2 presents a brief literature review regarding the public provision of quasi-private goods, and the provision rule

[4] See Garay (1994) and Fainboim et al (1994) for a description of the decentralisation process in Colombia.

used in the chapter. Section 3 presents the structure of the multiregional CGE model. Section 4 presents the quantification of the efficiency gains from decentralised provision of health and education in Colombia. Section 5 offers some concluding remarks.

2.2 PUBLIC PROVISION OF QUASI-PRIVATE GOODS: A BRIEF LITERATURE REVIEW

The literature concerning the provision of private goods by the public sector is scant. Since Arrows'(1971) public expenditure model, this literature has mainly concentrated on the characteristics of possible allocation rules, that is how a private good "should be" publicly provided (Blomquist and Christensen, 1994; Hare, 1988; Munro, 1991). This literature has also analysed issues such as the introduction of user charges (Besley, 1991; Balestrino, 1995), and the possibility of private market supplementation of the publicly provided private good (Epple and Romano, 1996; Blomquist and Christiansen, 1998).

Atkinson and Stiglitz (1980, Lecture 16) develop three models of public provision of private goods, where government intervention is justified on distributional grounds. In particular, they consider private goods that are freely provided to all consumers in a specified quantity, and cannot be traded by the individuals. These three models produce an optimal allocation which coincides with that obtained under free market conditions: that is, in the absence of government intervention, the level of provision of private goods for each individual is determined by the market, at the point where the marginal rate of substitution over consumption goods equals the marginal rate of transformation between these goods.

Besley and Coate (1991) develop a two-good general equilibrium model which shows that universal public provision[5] of private goods, such as health, housing and education, can redistribute income from the rich to the poor, even if the provision is financed through a head tax. Besley and Coate's model is a discrete choice model where individuals demand at most one unit of the good, and their decision as to whether to consume the good in the public or private sectors is based on quality considerations. These authors assume that the government provides a fixed quality level of the good (at zero price), which is typically not too high, and that the public provision is financed through a head tax. Under these circumstances, individuals with higher incomes may decide to pay for the good supplied by the private sector which offers a better quality level, rather than consuming the good provided by the government. The benefits from public provision will be mainly enjoyed by individuals with lower incomes. Nonetheless, the authors also find that universal provision schemes of private goods involve a dead-weight loss for the society as a whole. Besley and Coate's provision rule does not state how the fixed quality level and the head tax are determined.

The literature surveyed tells us the general features of possible provision rules in a normative sense. In practice, however, the government has to rely on surveys or other sources of information to infer the preferences of the population. The provision rule could be the result of a voting process. Since all consumers can benefit from the provision of the goods and services, the evident rule would be unanimous consent; however, it will take a long time to achieve unanimous consent and it encourages strategic behaviour (Mueller, 1989). In democratic societies, the majority rule is commonly chosen to make collective decisions. This rule introduces some

[5] Universal provision means that everybody is eligible and provision is free.

redistribution, since some individuals are going to be worse off than they would be if the other outcome had been chosen. The possibility of distributional gains also creates an incentive to form coalitions. Under the majority rule an equilibrium outcome is obtained when voter preferences are single-peaked. If these preferences can be depicted along a single dimension, as with an expenditure issue, the equilibrium lies at the peak-preference for the median voter (Mueller, 1989). It then follows that the median voter rule can be an alternative provision rule, where the demand for the good being provided by the government is determined by the median voter income. In order to apply the model empirically it is necessary to assume that the quantity of the good being provided is that demanded by the consumer with the median income (see Inman, 1978).

In the modelling approach used in this chapter, the quantity of the quasi-private good provided by the government is determined by the median voter provision rule. As Oates (1993) puts it, in the median voter framework the equilibrium level of local services is faithfully mirrored by the median of the preferred levels of outputs of local residents. That is, under decentralised provision, each regional government will determine the provision level of the quasi-private good according to the corresponding demand of the median voter. As one would expect, some individuals will be consuming more (or less) than they would have done being the good privately supplied. The public provision of the quasi-private good is financed by taxes, which results in transfers from consumers with high incomes to consumers with low incomes. Finally, the provision rule and the tax regime used to finance the provision of the good must be considered jointly, because of the distributional effects they have on the population.

In what follows, I describe the structure of the multiregional CGE model used to assess the welfare effects of the decentralised provision of quasi-private goods by the government.

2.3 STRUCTURE OF THE MULTIREGIONAL CGE MODEL

I use a CGE model to capture the welfare gains associated with the regional public provision of quasi-private goods, as compared to central provision. In this model the national economy is disaggregated into regions, since I am interested in the distributional effects among them. In addition, more than one consumer group is considered, since there are also distributional effects among consumers.

The model is for a closed economy consisting of R regions, each one with demand and production structures. Each region produces two types of goods: those that are provided by the public sector, and are thus referred to as the publicly provided quasi-private goods (henceforth PPQP); and those that are allocated by the market according to supply and demand conditions, and are thus referred to as the private goods (henceforth PRI). In the model, the PPQP goods are considered to be non-tradable across regions, whereas the PRI goods are considered to be qualitatively the same as those PRI goods produced by other regions. There are two factors of production, namely labour and capital; for simplicity, intermediate production is not considered. Each region has three groups of consumers and its own local government. There is also a national government.

2.3.1 PRODUCTION SIDE OF THE MODEL

A standard production structure is used, where each region produces two PPQP goods and three PRI goods. Constant elasticity of substitution (CES) production

functions describe the substitutability between labour (L) and capital (K) in the production of value added for each PRI good in each region, that is,

$$VA^{r}_{PRI_i} = \gamma^{r}_{i}\left(\delta^{r}_{i}\left(L^{r}_{PRI_i}\right)^{(\sigma^{r}_{i}-1)/\sigma^{r}_{i}} + \left(1-\delta^{r}_{i}\right)\left(K^{r}_{PRI_i}\right)^{(\sigma^{r}_{i}-1)/\sigma^{r}_{i}} \right)^{\sigma^{r}_{i}/(\sigma^{r}_{i}-1)}, \; i = 1,2,3 \qquad [1]$$

where $VA^{r}_{PRI_i}$ corresponds to value added of the PRI goods in region r; γ^{r}_{i} is a constant defining units of measurement; δ^{r}_{i} is a share parameter; $L^{r}_{PRI_i}$ denotes labour inputs in the production of the PRI goods; $K^{r}_{PRI_i}$ denotes capital inputs in the production of the PRI; and σ^{r}_{i} is the elasticity of substitution between labour and capital in the production of the PRI goods in region r. Each industry in each region selects an optimal level of inputs that minimises the cost of producing the goods. Regarding the PPQP goods, their production involves only labour. The formal equations and notation used in the model are presented in Appendix 2.1.

Factors of production are non-produced commodities in fixed supply in each region. It is assumed that both factors are mobile across industries within each region. Regarding interregional factor mobility, labour is assumed to be inter-regionally immobile since the analysis focuses on the interregional distributional effects of policy changes. The analysis excludes all the efficiency issues associated with regional labour movements. Capital is assumed to be inter-regionally mobile.

2.3.2 DEMAND SIDE OF THE MODEL

Each region has three groups of consumers. These can be thought of as low, medium, and high-income groups, since I am interested in the distributional effects of the decentralised provision of the PPQP goods within each region. Consumers differ in

their preferences for both PPQP and PRI goods, and this is the key element to obtain gains from decentralisation.

As mentioned earlier, in this modelling exercise the quantity of the PPQP goods to be publicly provided (either nationally or regionally) is determined by the median voter. Thus, the median voter (in the country or in each region, depending on which provision scenario is being considered) determines its optimal consumption bundle by maximising his utility function subject to his budget constraint. In particular, the median voter's behaviour is summarised by means of a CES utility function defined over PRI and PPQP goods, more formally,

$$U_M^r = \left(\sum_i \left(\alpha_{M,i}^r\right)^{1/\mu_M^r} \left(X_{M,i}^r\right)^{(\mu_M^r-1)/\mu_M^r} + \left(\alpha_{M,j}^r\right)^{1/\mu_M^r} \left(Q_{M,j}^r\right)^{(\mu_M^r-1)/\mu_M^r} \right)^{\mu_M^r/(\mu_M^r-1)} \quad [2]$$

where U_M^r is the utility function of the median voter, $\alpha_{M,i}^r$ and $\alpha_{M,j}^r$ are share parameters, $X_{M,i}^r$ is the demand of the median voter for the PRI good i, $Q_{M,j}^r$ is the demand of the median voter for the PPQP good j, and μ_M^r is the elasticity of substitution in consumption between PRI and PPQP goods.

The median voter's budget constraint is in turn given by income equal expenditure ($I_M^r = E_M^r$). Consumer's income is derived from factor ownership, whereas consumer's expenditure includes the amount spent on both PRI and PPQP goods as well as the taxes paid to finance the provision of the PPQP goods.

$$I_h^r = \sum_i P_{PRI_i} X_{h,i}^r + \sum_j \tilde{P}_{PPQP_j}^r Q_{h,j}^r + T_h^r \quad [3]$$

where the price paid by consumers for the PPQP goods ($\tilde{P}_{PPQP_j}^r$) corresponds to a fraction (ϕ^r) of the real cost of the good ($P_{PPQP_j}^r$). All consumers pay the same percentage, this means that all consumers in each region pay the same price. T_M^r

denotes taxes paid by the median voter, which correspond to either $T^r_M = I^r_M t$ or $T^r_M = I^r_M t^r$, depending on whether the provision is financed by national or regional taxes, respectively; in either case the tax rates t and t^r are endogenously determined. The median voter will take into account the cost to him of the provision as well as the taxes levied to finance such provision. Hence, both the quantity demanded of the PPQP goods and the tax rate(s) will be determined simultaneously.

The government takes the optimal quantities of the PPQP goods that result from the utility maximisation problem of the median voter to allocate to the other consumers. Other consumer groups (in the country or in the region) will in turn determine their optimal consumption bundle by maximising their utility functions subject to i) their budget constraints and ii) the exogenously determined quantities of the publicly provided quasi-private goods. The complete set of equations and notation that defines the demand side of the model is presented in Appendix 2.1.

2.3.3 NATIONAL AND REGIONAL GOVERNMENTS

Regarding the public sector, it is assumed that neither the central government nor the regional governments are optimising agents. The government, either national or local, provides the PPQP goods at a provision price ($\bar{P}^r_{PPQP_i}$), which could be zero. This provision price is a percentage (ϕ^r) of the cost covering price ($P^r_{PPQP_i}$), which implies that the government in charge of the provision, has to cover the difference between these prices. In order to do this, a uniform income tax (either national or regional) is introduced, which is endogenously determined and must be such that the zero government surplus condition is satisfied (that is income equals expenditure, I_G=E_G). In addition, a third financing alternative is considered which involves a

combination of national and regional taxes: the former is exogenously determined at a level of 0.05% whereas the latter are endogenously determined. In this case, the revenues generated by the national tax are transferred to regional governments.

Central government income is given by the revenues generated by the provision of the PPQP goods and tax revenues. On the other hand, government expenditure is given by the cost of provision of the PPQP goods and transfers to regional governments (TR^r). Since government income must equal government expenditure, the national tax rate can be calculated as:

$$t = \frac{\sum_{h,r,j} \left(P^r_{PPQP_j} - \tilde{P}^r_{PPQP_j}\right)\overline{Q}^r_{h,j} + \sum_{r} TR^r}{\sum_{h,r} \left(P^r_L \overline{L}^r_h + P_K \overline{K}^r_h\right)} \qquad [4]$$

If the provision of the PPQP goods is financed by regional taxes, the regional tax rate can be determined by equalising government income (i.e. the revenues generated by the provision of the PPQP goods, tax revenues and central government transfers) and expenditure (i.e. the cost of provision of the PPQP goods) in each region (see Appendix 2.1), that is:

$$t_r = \frac{\sum_{h,j} \left(P^r_{PPQP_j} - \tilde{P}^r_{PPQP_j}\right)\overline{Q}^r_{h,j} - TR^r}{\sum_{h} \left(P^r_L \overline{L}^r_h + P_K \overline{K}^r_h\right)} \qquad [5]$$

2.3.4 EQUILIBRIUM CONDITIONS IN THE MODEL

Once the model has been specified, it can be solved for an equilibrium solution. A general equilibrium in the model can be interpreted in the usual Walrasian sense as a set of prices for which all markets clear.

In equilibrium, demand-supply equalities hold in each goods and factors markets. In the goods market, gross output must equal final demand because intermediate production is netted out; specifically, the supply of the PRI goods must equal demand. In the case of the PPQP goods, the market clearing condition also indicates that supply must equal demand in each region.

Factors of production are assumed to be intersectorally mobile within each region; this means that there is only one price for each factor in each region as the model does not have sector specific factors of production. In addition, labour is assumed to be inter-regionally immobile, which means that there is a different price for labour in each region. Under this assumption, there are separate labour equilibrium conditions in each region. That is, the region's endowment of labour must equal factor use across industries (i.e. there is full employment in both regions). Capital is assumed to be inter-regionally mobile. This assumption implies that there is only one price for capital in the model, and this is determined by the market clearing condition that capital use across all industries and regions must equal the country's endowment of capital.

Zero profit conditions hold for each industry, in each region. These conditions state that in each region the value of sales must equal the industries' costs. And, budget balance conditions must be satisfied for the central government and regional governments alike, and also for consumers in each region. Appendix 2.1 presents the full set of equilibrium conditions of the model.

Having described the equilibrium conditions that characterise the model, I proceed to introduce the benchmark data set to be used in the simulations. In addition, the parameters of the model, that are consistent with the data set, have to be

calculated and these together with the elasticities (that are exogenously specified), allow us to reproduce the data set as an equilibrium solution of the model.

In the next section, the model described above is used to assess the welfare effects of the decentralised provision of PPQP goods in Colombia. I am particularly interested in quantifying to what extent will the Colombian population be better off under a provision scheme in which goods and services are delivered by regional governments, in comparison to a provision scheme in which goods and services are supplied by the central government.

2.4 QUANTIFYING THE WELFARE EFFECTS OF DECENTRALISATION IN COLOMBIA

Colombia has like many other countries engaged in a rather ambitious process of state decentralisation.[6] This process has followed the reforms carried out between 1988 and 1992 by the Colombian government in order to modernise the economy, which included areas such as foreign trade, foreign exchange regime, fiscal legislation, the financial sector and the labour market.[7]

Using data for 1992, in this section a multiregional CGE model for the Colombian economy is built in order to quantify the welfare effects of the decentralised provision of quasi-private goods by the government. I will be dealing with a simplified version of the Colombian economy, in the sense that aspects such as foreign trade are not considered.

[6] In the country there have been two national commissions to study decentralisation: Departamento Nacional de Planeación (1981) and Wiesner (1992).
[7] See Urrutia(1994) for a presentation of these reforms.

2.4.1 BENCHMARK DATA SET, CALIBRATION AND ELASTICITIES

Colombia comprises 33 provinces (or administrative regions). The complexities of a model with 33 regions are of secondary relevance to the problem being studied, so that these provinces were grouped according to the geographical classification of the country. Colombia is divided in five so-called "natural" or geographic regions: Pacific, Atlantic, Andean, Amazonia, and Orinoquia. Due to data constraints, Amazonia and Orinoquia are considered as one region. Hence, there are four regions of different size. The Andean region accounts for 63% of the country's GDP, the Pacific and Atlantic regions each accounts for 15% of GDP, and the Amazonia and Orinoquia (henceforth A&O) region accounts for the remaining 7% of GDP.

To assess the sensitivity of the results to the regional classification, the country was also divided into three regions according to the GDP of each province. Administrative regions with the lowest GDP were grouped in region one, those with medium GDP were grouped in region two, and those with the highest GDP are in region three. In addition to the geographic and GDP classifications, provinces were classified in five regions according to agricultural GDP, with the provinces with the lowest agricultural GDP grouped in region one, and those with the highest in region five. Appendix 2.2 presents the regional classifications of the country according to the different criteria.

Turning to the commodities in the model, each region is assumed to produce three PRI goods and two PPQP goods. The former includes primary commodities (including fuels), manufactured goods, and services, whereas the latter corresponds to health and education. It is assumed that each region's PRI goods are qualitatively the same. It should be mentioned that in Colombia the majority of education and health services are provided by the private sector. However, from the available data it

is only possible to determine the value of the education and health services provided by the government (i.e. 0.4% and 2.3% of GDP, respectively), but not by the private sector. For this reason, the existence of pure private provision of education and health is not considered in the analysis.

The benchmark data set involves data on value added by component by industry, and domestic consumption. It was constructed using data from Regional Accounts, as compiled by DANE (1995b), and following the methodology presented by St-Hilaire and Whalley (1987). In this methodology, each region is treated as a separate economy, in which production and demand transactions by commodity at the regional level are presented. The data set also includes transactions between regions (e.g. commodity trade), payments of taxes by region as well as government expenditure. The equilibrium conditions that characterise the model are present in the data set, that is the value of final demands for each good in each region must equal the value of net supply (i.e., excluding intermediate supply), each consumer group satisfies its budget constraint, and budget balance conditions must be satisfied for the central government and regional governments alike. A detailed presentation of the sources and how the data set was assembled is presented in Appendix 2.2.

Table 2.1 presents the resulting Colombian regional data set using the geographic classification (the other two data sets are presented in Appendix 2.2). The table presents production and demands by commodity along with consumers and government(s) income and expenditure accounts. On the production side, labour and capital are used to produce the PRI goods in each region; as to the PPQP goods, labour is the only factor that enters in their production.

Table 2.1: Colombian regional data set
Regional classification according to geographic regions
(Col$ billion)

Production side: Primary inputs

	Pacific region			Atlantic region			Andean region			A&O region			Total
	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Value Added
Primary goods	389.7	587.0	976.6	507.5	1,029.9	1,537.4	1,252.2	2,289.6	3,541.8	288.8	971.0	1,259.8	7,315.6
Manufactures	398.4	451.2	849.5	318.5	360.7	679.2	1,588.9	1,799.5	3,388.4	20.2	22.9	43.1	4,960.3
Services	1,169.7	1,426.1	2,595.8	1,013.8	1,242.8	2,256.6	5,314.3	6,204.4	11,518.7	343.5	411.3	754.8	17,125.9
Education													
Pacific region	17.3	0.0	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.3
Atlantic region	0.0	0.0	0.0	15.2	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	15.2
Andean region	0.0	0.0	0.0	0.0	0.0	0.0	88.9	0.0	88.9	0.0	0.0	0.0	88.9
A&O region	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	5.4	5.4
Health													
Pacific region	102.4	0.0	102.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.4
Atlantic region	0.0	0.0	0.0	89.9	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	89.9
Andean region	0.0	0.0	0.0	0.0	0.0	0.0	527.1	0.0	527.1	0.0	0.0	0.0	527.1
A&O region	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	0.0	31.7	31.7
Total	2,077.3	2,464.2	4,541.6	1,944.8	2,633.4	4,578.2	8,771.5	10,293.5	19,065.0	689.7	1,405.2	2,094.8	30,279.6

Demand side: Final demands

	Pacific region			Atlantic region			Andean region			A&O region			
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Total
Primary goods	234.0	419.9	322.7	368.4	661.0	507.9	848.8	1,522.9	1,170.1	302.7	555.3	401.9	7,315.6
Manufactures	200.8	339.5	309.3	160.6	271.4	247.3	801.0	1,354.0	1,233.5	9.5	18.4	15.2	4,960.3
Services	345.5	911.4	1,338.9	300.3	792.3	1,163.9	1,533.0	4,044.4	5,941.3	101.7	253.4	399.7	17,125.9
Education													
Pacific region	2.3	5.7	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.3
Atlantic region	0.0	0.0	0.0	2.1	5.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	15.2
Andean region	0.0	0.0	0.0	0.0	0.0	0.0	12.1	29.6	47.3	0.0	0.0	0.0	88.9
A&O region	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.8	2.7	5.4
Health													
Pacific region	13.9	34.0	54.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.4
Atlantic region	0.0	0.0	0.0	12.2	29.9	47.8	0.0	0.0	0.0	0.0	0.0	0.0	89.9
Andean region	0.0	0.0	0.0	0.0	0.0	0.0	71.6	175.3	280.3	0.0	0.0	0.0	527.1
A&O region	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.6	16.1	31.7
Total	796.6	1,710.6	2,034.4	843.6	1,759.7	1,975.0	3,266.4	7,126.1	8,672.4	419.7	839.5	835.6	30,279.6

Consumers income and expenditure accounts

	Pacific region			Atlantic region			Andean region			A&O region			
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Total
Income:													
Labour income	364.4	782.4	930.6	358.3	747.5	839.0	1,502.8	3,278.6	3,990.1	138.2	276.4	275.1	13,483.3
Capital income	432.2	928.2	1,103.9	485.2	1,012.2	1,136.0	1,763.6	3,847.5	4,682.4	281.5	563.1	560.5	16,796.3
Total income	796.6	1,710.6	2,034.4	843.6	1,759.7	1,975.0	3,266.4	7,126.1	8,672.4	419.7	839.5	835.6	30,279.6
Expenditure:													
Final demand	796.6	1,710.6	2,034.4	843.6	1,759.7	1,975.0	3,266.4	7,126.1	8,672.4	419.7	839.5	835.6	30,279.6
Taxes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total expenditure	796.6	1,710.6	2,034.4	843.6	1,759.7	1,975.0	3,266.4	7,126.1	8,672.4	419.7	839.5	835.6	30,279.6

Government income and expenditure accounts

Income:	
Provision Education	126.7
Provision Health	751.1
Tax collections	0.0
Total income	877.8
Expenditure:	
Cost provision Educ:	126.7
Cost provision Healt	751.1
Total expenditure	877.8

Source: DANE (1995b) and author's calculations.

On the demand side, consumers demand both types of goods, and it is initially assumed that consumers pay the full cost of the goods provided by the government. The consumers income and expenditure accounts show that income generates from factor ownership, that is consumers own both factors of production, while expenditure corresponds to final demand. Lastly, government income is given by the revenues generated by the provision of the PPQP goods and tax collections (although initially it is assumed that there are no taxes); government expenditure is in turn given by the cost of provision of the PPQP goods.

At this point, it is important to mention that in the data set, derived from Colombian 1992 data, the PPQP goods are provided according to the preferences of each consumer group, with each one of them demanding different quantities of the goods. This seems inconsistent with the fact that the observed data is based on a period in which the PPQP goods were delivered by the central government. It would be ideal to allow the benchmark data set to represent the scenario in which the PPQP are delivered by the central government. However, there are problems with this approximation, since there is not information available to explain the differences between the levels of provision between consumer groups and between regions. The benchmark data set in Table 2.1 is therefore used as a starting point to calculate the quantities of the PPQP goods provided by central and regional governments.

Once the data set has been assembled, some parameter values, such as share parameters and scale parameters, can be directly calculated from the equilibrium conditions of the model, following the procedure described in Mansur and Whalley (1984). This procedure is known as calibration, and can be understood as the ability of the model to reproduce base year data as a model solution. The benchmark data set provides information on equilibrium transactions in value terms. The first step of the

calibration procedure involves the separation of these transactions into price and quantity observations. In order to do this, a units convention is widely used, in which it is assumed that a physical unit of each good and factor is the amount that sells for one currency unit (in this case, one Colombian peso). That is, both goods and factors have a price of unity in the benchmark equilibrium.

The next step in the calibration procedure is to calculate parameters for production functions from the benchmark equilibrium. observations, given the required values of pre-specified elasticities. As CES functional forms are used, substitution elasticities must be exogenously determined. On the demand side, the model involves elasticities of substitution in consumption between PRI and PPQP goods. In this case, it was not possible to find econometric estimates, then this elasticity was set equal to one in all regions; these elasticities imply Cobb-Douglas demand functions. Regarding the supply side, the elasticity of substitution between labour and capital is the key parameter of the value-added functions of the PRI goods (see Table 2.2). These elasticities were calculated as weighted averages of the elasticities presented in Whalley (1985, p. 100). This elasticity is not required in the production of the PPQP goods, since their production only involves labour.

Table 2.2: Elasticities used in the model

	Elasticity of factor substitution in the production of the PRI goods (σ_i^r)		
	Primary commodities	Manufactured goods	Services
Pacific	0.70	0.81	1.00
Atlantic	0.80	0.81	1.00
Andean	0.72	0.81	1.00
A&O	0.76	0.81	1.00

Notes:
Elasticities of substitution based on those reported in Whalley (1985; p.100).

The results of the model are dependent on the values selected for the elasticities of substitution. In addition, consumption effects, which also depend on the elasticities chosen, determine the welfare effects of any policy change. Sensitivity analysis is performed around the values chosen.

Once these parameters have been specified, share parameters can be obtained from demand functions. On the supply side, share and scale parameters can be obtained from cost functions. The model was solved using a routine I wrote in the General Algebraic Modelling System (GAMS) software.

2.4.2 MODEL RESULTS

In this section, counterfactual experiments are performed in order to analyse the welfare effects of the decentralised provision of PPQP goods, as measured by the equivalent variation (EV). In the applied general equilibrium literature, welfare measures focus on comparisons between equilibria. The EV is the minimum amount that someone who gains from a particular change would be willing to accept to forego the change. In the case of an individual who loses from the change, the EV is the maximum he would be willing to pay to prevent that change. The measure of EV can be written as:

$$EV = E(U^N, P^0) - E(U^0, P^0)$$

As can be seen, the EV compares the utility levels achieved before and after the change (U^0 and U^N, respectively) at the initial equilibrium prices (P^0). Following Shoven and Whalley (1992, p.125), when preferences are linear homogeneous the EV can be written as:

$$EV = \left(\frac{U^N - U^0}{U^0} \right) I^0$$

where I^0 denotes the initial disposable income.

In the analysis that follows, two provision scenarios are compared: national versus regional. In other words, I move from the scenario in which the provision is carried out by the central government to that in which PPQP goods are delivered by regional governments.

In the national provision scenario, uniform quantities of the PPQP goods are provided to all consumer groups across the country. These quantities correspond to the optimal demands derived from the utility maximisation problem of the median voter of the country. In the regional provision scenario, uniform quantities of the PPQP goods are provided to all consumers in each region, and these quantities correspond to the optimal demands obtained from the utility maximisation problems of the median voters in each region. It is important to bear in mind that since secondary data are used, it is likely that the share parameters in the utility functions are not the best. Then, it is assumed that the information contained in the benchmark data set reflect consumers preferences.

Since it is assumed that consumers pay a fraction of the cost of the PPQP goods, the government finances the remaining part for which three financing alternatives are considered: a) a national income tax; b) two regional income taxes; and c) a combination of a national tax and two regional taxes. Counterfactual experiments were carried out for the cases where the government finances 20%, 50%, 70%, and 100% of the cost of provision of the goods, although for brevity I shall focus on the case where consumers pay 50% and the country is divided in four geographical regions. The new tax rate(s) is(are) endogenously determined and must be such that the zero government budget surplus condition is satisfied. Tax rates are

calculated using equation [4] when provision is financed by a national tax, or [5] when using regional taxation.

Tax rates are expected to be larger as the percentage of the cost of provision of the PPQP goods paid by consumers gets smaller, because the government has to cover larger subsidies. In addition, the fact that consumers pay only a fraction of the cost of provision of the PPQP goods and that the government finances the remaining part, means that some consumer groups pay less than they should pay, whereas other groups pay more.

When uniform quantities of the PPQP goods are provided to all consumer groups across the country, consumers are allocated the optimal quantities demanded by consumer group two in the Atlantic region (the median voter of the country).[8] When the provision takes into account regional differences, uniform quantities of the PPQP goods are allocated to all consumers in each region corresponding to the optimal quantities demanded by the median voter of each region, in this case consumer group two (Appendix 2.3 presents the quantities allocated to each consumer group in both provision scenarios).

It is important to mention that when the provision, either national or regional, is financed by a national tax, the quantity demanded by the median voter increases as the percentage of the cost of provision paid by the consumer reduces, since the cost of the provision is covered by all consumers in the country. By contrast, when the provision is financed by regional taxes or a combination of regional and national taxes, the quantity demanded by the median voter reduces as the percentage of the

[8] In strict sense, the median quantity would correspond to the average of the resulting quantities of the utility maximisation problem of consumer groups two in the Atlantic and Pacific regions because there is an even number of consumers in the country. To simplify the solution of the model, it was decided to consider only the results of consumer group two in the Atlantic region.

cost of provision paid by the consumer increases, since the cost of the provision is now covered only by the consumers in the region.

Table 2.3 presents the tax rates obtained under the three financing alternatives, along with the subsidies received by consumers when they pay 50% of the cost of provision (Appendix 2.4 reports the results when consumers pay 80%, 30%, and 0% of the cost of provision). This table shows that when provision is carried out nationally, consumers in the Andean region are subsidising the provision of health and education for the rest of the country (i.e. there is redistribution among regions). The Andean region is the most densely populated region (around 60% of the population lives there) and is also the most industrialised one. If, on the other hand, provision follows regional preferences, consumer groups two and three in the Andean and A&O regions contribute to finance not only the provision of consumer group one in their respective region, but also the provision of the poorest consumer group in the Pacific and Atlantic regions. In this case there is redistribution within regions and among them.

Table 2.3: Tax rates and subsidies when consumers pay 50% of the cost of provision (Col $ billions)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
1. *Tax rates*			
National provision			
Pacific	0.8%	1.1%	1.0%
Atlantic	0.8%	1.1%	1.0%
Andean	0.8%	0.3%	0.2%
A&O	0.8%	2.3%	2.1%
Regional provision			
Pacific	1.9%	1.2%	1.1%
Atlantic	1.9%	1.1%	1.0%
Andean	1.9%	1.5%	1.5%
A&O	1.9%	0.8%	0.6%
2. *Subsidies*			
National provision			
Pacific			
Consumer 1	14.3	7.7	7.9
Consumer 2	7.2	-2.1	-1.5
Consumer 3	4.6	-5.6	-4.9
Atlantic			
Consumer 1	12.8	7.3	7.5
Consumer 2	5.8	-2.5	-1.9
Consumer 3	4.2	-4.8	-4.1
Andean			
Consumer 1	-5.0	7.9	6.9
Consumer 2	-35.4	-2.0	-4.1
Consumer 3	-47.4	-5.9	-8.5
A&O			
Consumer 1	15.1	6.5	7.0
Consumer 2	11.9	-3.3	-2.2
Consumer 3	11.9	-3.2	-2.1

Table 2.3 (Continued): Tax rates and subsidies when consumers pay 50% of the cost of provision
(Col $ billions)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
Regional provision			
Pacific			
Consumer 1	18.4	8.8	9.1
Consumer 2	0.8	-2.4	-1.9
Consumer 3	-5.5	-6.4	-5.7
Atlantic			
Consumer 1	13.2	7.3	7.5
Consumer 2	-4.4	-2.5	-1.9
Consumer 3	-8.5	-4.8	-4.1
Andean			
Consumer 1	56.9	46.9	45.9
Consumer 2	-17.4	-11.7	-13.9
Consumer 3	-47.1	-35.2	-37.8
A&O			
Consumer 1	3.2	2.2	2.8
Consumer 2	-4.8	-1.1	-0.0
Consumer 3	-4.8	-1.1	-0.0

Note:
The subsidy is calculated as the cost of provision of the PPQP goods, minus the value paid by the consumer and the income tax.

When the provision is financed by regional taxes and carried out centrally, taxes are higher in the Pacific, Atlantic, and A&O regions than in the Andean region because the cost of provision represents a higher proportion of these region's income. When the provision is carried out regionally, tax rates are lower in all regions (compared to regional provision financed by a national tax) because smaller quantities of the PPQP goods, more in line with consumers' preferences, need to be financed.

Regarding subsidies, consumer groups two and three in each region subsidise consumer group one in both provision scenarios. In this case there is redistribution within the regions. As the percentage paid by consumers for the provision of the good falls, subsidies increase since higher taxes are required to balance the budget of the government. For example, when consumers pay 50% of the cost of provision, and the provision is carried out by the central government, consumer group one in the Pacific region receives Col$7.7 billion (see Table 2.3); when consumers pay 30% and 0%, the subsidy increases to Col$10.5 billion and Col$14.3 billion, respectively (see Appendix 2.4).

When the government finances the provision of the PPQP good with a 0.05% national tax and regional taxes, tax rates are lower than when only regional taxes are used, because the revenues generated by the national tax are transferred back to regional governments. It was assumed that 25% of the tax revenues raised by the national tax were transferred to each regional government. This percentage can be used as a policy instrument in order to redistribute income from the richest to the poorest regions. With the transfers the central government helps to cover part of the cost of provision of the PPQP goods, so that less regional taxes are needed. In the other financing alternatives there are no transfers from the central to regional governments. In this financing alternative, under both provision scenarios the two richest consumer groups in the Andean region are not only subsidising consumer group one in that region but also helping to finance the provision of consumer group one in the other three regions. In this case there is redistribution from the richest region to the poorest, and from the richest consumer group to the poorest consumer groups.

Now, let us consider the welfare effects of the decentralised provision of the PPQP goods. Both provision scenarios are compared (i.e., central versus regional) and the resulting efficiency gains (losses) are presented in Table 2.4 for each region and for the economy as a whole.[9] As can be seen from the table, whether the provision is financed with a national tax, regional taxes, or a combination of a 0.05% national tax and four regional taxes, the society as a whole gains from decentralised provision(except when the provision is financed by a national tax and the goods are provided free of charge). This is the case since under regional provision the quantity of the PPQP good supplied to consumers is more in line with their preferences. In addition, the welfare gains vary from 1.3% to 2.3% of GDP.[10] Notice that when the provision is financed with a national tax, the Andean region benefits the most from decentralisation, despite the fact that consumers in this region are subsidising the provision of consumers in other regions. As the percentage of the cost of provision reduces, the Andean region gains become losses since higher taxes are required. The Pacific region is worse off because of reduced aggregate consumption. The Atlantic and A&O regions are in some cases worse off; the decentralised provision of the PPQP goods increases considerably the quantity allocated to these two regions (when the percentage of the cost of provision paid by consumers is 30% and 0%), leading to a considerable reduction in the consumption of PRI goods; yet, the increased consumption of the PPQP goods is not enough to compensate the reduction in welfare due to the reduced consumption of the PRI goods.

[9] Regional equivalent variations were calculated as the arithmetic sum of individual equivalent variations summed across consumer groups. The aggregate welfare change was calculated using an arithmetic sum of regional equivalent variations. Problems associated to this procedure are discussed in Boadway (1974) and Boadway and Bruce (1984).

[10] Welfare gains are similar when 25% of the revenues raised by the national tax are transferred to the Pacific region, 25% to the Atlantic region, 10% to the Andean region, and 40% to the A&O region.

Table 2.4: Welfare effects of decentralisation
(Col$ billion)

	Percentage of the cost of provision paid by consumers							
	80%		50%		30%		0%	
	EV	%GDP	EV	%GDP	EV	%GDP	EV	%GDP
1. *National tax*								
Pacific	-33.5	-0.1%	-50.6	-0.2%	-61.9	-0.2%	-292.0	-1.0%
Atlantic	78.9	0.3%	38.8	0.1%	-2.5	-0.0%	317.7	1.0%
Andean	540.6	1.8%	529.0	1.7%	466.9	1.5%	-884.6	-2.9%
A&O	49.1	0.2%	15.8	0.1%	-12.5	-0.0%	135.1	0.4%
Total	635.1	2.1%	533.0	1.8%	390.0	1.3%	-723.8	-2.4%
2. *Regional taxes*								
Pacific	1.4	0.0%	2.1	0.0%	2.6	0.0%	3.3	0.0%
Atlantic	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Andean	612.4	2.0%	633.9	2.1%	647.3	2.1%	666.3	2.2%
A&O	28.4	0.1%	24.9	0.1%	22.8	0.1%	19.9	0.1%
Total	642.2	2.1%	660.9	2.2%	672.7	2.2%	689.5	2.3%
3. *Regional taxes and a 0.05% national tax*								
Pacific	1.5	0.0%	2.2	0.0%	2.6	0.0%	3.3	0.0%
Atlantic	195.6	0.6%	199.3	0.7%	400.7	1.3%	593.0	2.0%
Andean	441.9	1.5%	444.9	1.5%	249.9	0.8%	87.3	0.3%
A&O	3.2	0.0%	14.5	0.0%	19.2	0.1%	5.6	0.0%
Total	642.2	2.1%	660.9	2.2%	672.4	2.2%	689.2	2.3%

Note: Totals may not add up because of rounding.

When the provision of education and health is financed with a national tax, welfare losses in the Pacific region increase as the percentage of the cost of provision paid by consumers reduces. Welfare gains in the A&O region become welfare losses as the percentage paid by consumers reduce; these losses are generated by a reduction in disposable income, because of higher taxes, since they are contributing to finance the poorest consumer in the Pacific and Atlantic regions. In the Andean region, welfare gains increase as the percentage paid by consumers increase; this is the result of increased aggregate consumption caused by the increase in disposable income resulting from lower taxes.

It is interesting to notice that when the provision is financed with either regional taxes or a combination of national and regional taxes, all regions are better off as a result of the decentralised provision of health and education. Further, welfare gains are larger than when the provision is financed with a national tax alone.

Welfare gains of similar magnitude can be observed when the country is divided into three regions according to regional GDP, ranging from 1.4% to 2.3% of GDP. In addition, welfare losses of 1.2% of GDP are obtained when the provision is financed by a national tax and is free of charge (see Table 2.5). When the country is divided into five regions according to agricultural GDP, welfare gains vary between 0.5% and 1.4% of GDP. Welfare losses are also obtained (in this case they amount to 4.7% of GDP) when the provision is financed by a national tax and consumers pay 0% of the cost of provision (see Table 2.6). The magnitude of the welfare gains from decentralised provision is substantial, especially when compared to those resulting from the tax reforms carried out between 1990 and 1992, which have been estimated to account for only 0.2% of GDP (see Lora and Herrera, 1994). These results suggest that regional differences are very important, not only the number of regions, but also the preferences for the goods to be publicly provided. The more different the preferences among regions, the better chance for considerable welfare gains.

Table 2.5: Welfare effects of decentralisation
(Equivalent variation as a percentage of the country's GDP)
Regional classification according to regional GDP
(Col$ billion)

	Percentage of the cost of provision paid by consumers:			
	80%	50%	30%	0%
1. *National tax*				
Region 1	0.3%	0.2%	0.0%	0.0%
Region 2	0.6%	0.4%	0.2%	-0.1%
Region 3	1.3%	1.3%	1.1%	-1.0%
Total	2.3%	1.8%	1.4%	-1.2%
2. *Regional taxes*				
Region 1	0.2%	0.2%	0.2%	0.2%
Region 2	0.0%	0.0%	0.0%	0.0%
Region 3	1.7%	1.7%	1.8%	1.9%
Total	1.9%	2.0%	2.0%	2.0%
3. *Regional taxes and a 0.05% national tax*				
Region 1	0.2%	0.2%	0.2%	0.2%
Region 2	0.0%	0.0%	0.0%	0.0%
Region 3	1.7%	1.7%	1.8%	1.9%
Total	1.9%	2.0%	2.0%	2.0%

Table 2.6: Welfare effects of decentralisation
(Equivalent variation as a percentage of the country's GDP)
Regional classification according to agricultural GDP
(Col$ billion)

	Percentage of the cost of provision paid by consumers:			
	80%	50%	30%	0%
1. *National tax*				
Region 1	0.2%	0.0%	-0.1%	-0.4%
Region 2	0.9%	1.0%	1.1%	-0.2%
Region 3	0.0%	-0.1%	-0.2%	-0.7%
Region 4	0.0%	-0.1%	-0.2%	-0.7%
Region 5	0.4%	0.3%	-0.1%	-2.9%
Total	1.4%	1.1%	0.5%	-4.7%
2. *Regional taxes*				
Region 1	0.3%	0.3%	0.4%	0.5%
Region 2	0.5%	0.4%	0.3%	0.1%
Region 3	0.0%	0.0%	0.1%	0.1%
Region 4	0.0%	0.0%	0.0%	0.1%
Region 5	0.2%	0.2%	0.1%	0.0%
Total	1.0%	0.9%	0.9%	0.9%
3. *Regional taxes and a 0.05% national tax*				
Region 1	0.3%	0.3%	0.4%	0.5%
Region 2	0.5%	0.4%	0.3%	0.1%
Region 3	0.0%	0.0%	0.1%	0.1%
Region 4	0.0%	0.0%	0.0%	0.1%
Region 5	0.2%	0.2%	0.1%	0.0%
Total	1.0%	0.9%	0.9%	0.9%

Finally, it is also worth mentioning that the same set of counterfactuals were carried out using data for a hypothetical economy that differs from the Colombian data set in four important respects. First, the hypothetical data set shows a more substantial income gap between the regions (the income of the richest consumer in region one is assumed to be a third of the income of the poorest consumer in region two). Second, output in the richest region accounts for 86% of total output whereas in Colombia there is less concentration. Third, the relative importance of the PPQP goods in total output is approximately one-third, compared to approximately 3% in the Colombian data set. And, preferences for the PPQP goods vary considerably

across regions. Using the artificial data set, the efficiency gains from decentralisation were much larger than those obtained with the Colombian data. For example, assuming that consumers pay 50% of the cost of provision, welfare gains reached approximately 8% of GDP when the provision was financed by a national tax, 14% of GDP when the provision was financed by two regional taxes, and 9% of GDP when the provision was financed by a combination of a national tax and two regional taxes.

2.4.3 SENSITIVITY ANALYSIS

Sensitivity analyses were carried out on the elasticities used in the model in order to evaluate changes in the model's response to a different set of values. The elasticities involved are: the elasticity of substitution in consumption between PRI and PPQP goods, and the elasticity of factor substitution in value added of the PRI goods.

First, let us consider the elasticity of substitution in consumption between PRI and PPQP goods (denoted μ_h^r). This elasticity is important because consumption effects, which depend on the elasticities chosen, determine the welfare effects of any policy change. Uniform values for these substitution elasticities of 0.5, 0.7, 1.2 and 1.5 are used; the first two values are smaller that the one used in the model, whereas the other two values are larger. The results of the sensitivity analyses are summarised in Table 2.7. The main predictions of the model do not change, in the sense that independently of the financing alternative the decentralised provision of PPQP goods generates welfare gains, except when the provision is financed by a national tax and consumers pay 0% of the cost of provision of the goods. However, the magnitude of the welfare gains is sensitive to the value of the elasticity chosen; in particular, the larger the elasticity of substitution the smaller the welfare gains. When the provision

is financed by a national tax and consumers pay 0% of the cost of provision, welfare gains reduce as μ_h^r increases. This means that as the goods become more substitutes in consumption there is less room for welfare gains as a result of increased consumption of the goods.

Table 2.7: Sensitivity analysis
Welfare effects of the decentralised provision of PPQP goods
(Equivalent variation as a percentage of GDP)
Elasticity of substitution in consumption μ_h^r

Percentage paid by consumers (PP):	$\mu_h^r = 0.5$	$\mu_h^r = 0.7$	$\mu_h^r = 1.0$	$\mu_h^r = 1.2$	$\mu_h^r = 1.5$
1. *National tax*					
PP=80%	10.2%	4.3%	2.1%	1.9%	1.1%
PP=50%	8.6%	3.6%	1.8%	1.7%	0.9%
PP=30%	7.2%	2.9%	1.3%	1.3%	0.6%
PP=0%	1.4%	-1.5%	-2.4%	-2.4%	-2.4%
2. *Regional taxes*					
PP=80%	11.1%	4.5%	2.1%	1.5%	1.1%
PP=50%	11.7%	4.6%	2.2%	1.6%	1.1%
PP=30%	12.1%	4.8%	2.2%	1.6%	1.1%
PP=0%	12.6%	4.9%	2.3%	1.6%	1.1%
3. *Regional taxes and national tax of 0.05%*					
PP=80%	11.1%	4.5%	2.1%	1.5%	1.1%
PP=50%	11.7%	4.6%	2.2%	1.6%	1.1%
PP=30%	12.1%	4.8%	2.2%	1.6%	1.1%
PP=0%	12.6%	4.9%	2.3%	1.6%	1.1%

Let us now turn to the elasticity of substitution between labour and capital in the production of the PRI goods (denoted σ_i^r). The central case elasticities varied between 0.7 and 1.0 (see Table 2.2). There is no consensus as to the orders of magnitude involved; most time series estimates locate these elasticities around one whereas cross section estimates are often around 0.5 (Whalley, 1985). I use uniform values for these substitution elasticities in the range 0.5 to 1.5. The results of the model are robust to the value of the elasticities chosen with aggregate welfare gains

accounting for approximately 2.3% of GDP, as in the central case specification when the provision is financed by either regional taxes or a combination of national and regional taxes. When the provision of the PPQP goods is financed by a national tax, as labour and capital become more substitutes in the production of the PRI goods, welfare gains reduce slightly; for example, when consumers pay 50% of the cost of provision welfare gains reduce from 1.9% to 1.7% of GDP (see Table 2.8).

Table 2.8: Sensitivity analysis
Welfare effects of the decentralised provision of PPQP goods
(Equivalent variation as a percentage of GDP)
Elasticity of substitution in production of the PRI goods σ_i^r

Percentage paid by consumers (PP):	σ_i^r=0.5	σ_i^r=0.7	σ_i^r=1.0	σ_i^r=1.2	σ_i^r=1.5
1. *National tax*					
PP=80%	2.2%	2.1%	2.1%	2.1%	2.0%
PP=50%	1.9%	1.8%	1.7%	1.7%	1.7%
PP=30%	1.4%	1.3%	1.3%	1.3%	1.2%
PP=0%	-2.7%	-2.5%	-2.3%	-2.2%	-2.1%
2. *Regional taxes*					
PP=80%	2.1%	2.1%	2.1%	2.1%	2.1%
PP=50%	2.2%	2.2%	2.2%	2.2%	2.2%
PP=30%	2.2%	2.2%	2.2%	2.2%	2.2%
PP=0%	2.3%	2.3%	2.3%	2.3%	2.3%
3. *Regional taxes and national tax of 0.05%*					
PP=80%	2.1%	2.1%	2.1%	2.1%	2.1%
PP=50%	2.2%	2.2%	2.2%	2.2%	2.2%
PP=30%	2.2%	2.2%	2.2%	2.2%	2.2%
PP=0%	2.3%	2.3%	2.3%	2.3%	2.3%

2.5 CONCLUDING REMARKS

This chapter has presented numerical results on the welfare effects of the decentralised provision of health and education using a multiregional CGE model for Colombia. Two provision scenarios were compared: one in which goods and services are supplied according to national preferences, as opposed to one where goods and

services are delivered following regional preferences. When the provision is carried out nationally, consumers groups across the country are provided with uniform quantities of the goods, and these are determined by the median voter of the country. When the provision is carried out regionally, uniform quantities of the goods are provided for all consumer groups in each region, and these quantities are determined by the corresponding regional median voter. In the model, consumers pay a fraction of the cost of the PPQP goods, and the government finances the remaining part using a national income tax, regional income taxes, or a combination of the two.

The results show that the decentralised provision of education and health improves the welfare of the Colombian population as a whole (except in the case when the provision is free of charge). It is worth pointing out that not all regions benefit when the provision is financed by a national tax; the Andean and the A&O regions subsidise the provision of the Pacific and Atlantic regions. When the provision is financed by regional taxes or a combination of national and regional taxes, all regions benefit from decentralised provision.

The main conclusion that arises from this modelling exercise, is that the society as a whole is better off when the provision of health and education is carried out regionally as opposed to centrally: with regional provision, each consumer group is allocated amounts of the goods that are closer to its preferences. More importantly, these welfare gains vary between 1.3% and 2.3% of GDP, a substantial magnitude especially when compared with the estimated efficiency gains associated to the tax reforms of the early nineties. When the country was divided into three and five regions, the welfare gains of decentralisation vary between 1.4% and 2.3% of GDP and between 0.5% and 1.4% of GDP, respectively. This result suggest that regional differences are very important, not only the number of regions, but also the

preferences for the goods to be publicly provided. The more different the preferences among regions, the better chance for considerable welfare gains.

Finally, it is worth mentioning that from the policy point of view, decentralisation properly implemented can provide important economic and political benefits to regions, as local governments deliver services more efficiently and are accountable for public spending. Decentralisation not only involves the allocation of expenditure responsibility and/or more fiscal powers to sub-national levels of government. It also requires the provision of the necessary resources and the development of adequate institutional support and public expenditure management structures, if the results are to be socially and economically beneficial. The question is then, as McLure (1995) puts it, how to do it well, since decentralisation badly done can reduce welfare, increase income disparities among regions, and aggravate fiscal problems and corruption, among others.

Appendix 2.1: Model equations and notation

Production side of the model

- Value-added functions

$$VA^r_{PRI_i} = \gamma^r_i \left(\delta^r_i \left(L^r_{PRI_i}\right)^{(\sigma^r_i - 1)/\sigma^r_i} + (1-\delta^r_i)\left(K^r_{PRI_i}\right)^{(\sigma^r_i - 1)/\sigma^r_i} \right)^{\sigma^r_i/(\sigma^r_i - 1)} \quad [A2.1]$$

$$VA^r_{PPQP_j} = L^r_{PPQP_j} \quad [A2.2]$$

Demand side of the model

- Utility function

1. Median voter

$$U^r_M = \left(\sum_i \left(\alpha^r_{M,i}\right)^{1/\mu^r_M} \left(X^r_{M,i}\right)^{(\mu^r_M - 1)/\mu^r_M} + \left(\alpha^r_{M,j}\right)^{1/\mu^r_M} \left(Q^r_{M,i}\right)^{(\mu^r_M - 1)/\mu^r_M} \right)^{\mu^r_M/(\mu^r_M - 1)} \quad [A2.3]$$

2. Other consumers

$$U^r_h = \left(\sum_i \left(\alpha^r_{h,i}\right)^{1/\mu^r_h} \left(X^r_{h,i}\right)^{(\mu^r_h - 1)/\mu^r_h} + \left(\alpha^r_{h,j}\right)^{1/\mu^r_h} \left(\overline{Q}^r_{h,j}\right)^{(\mu^r_h - 1)/\mu^r_h} \right)^{\mu^r_h/(\mu^r_h - 1)}, \; h \neq M \quad [A2.4]$$

Constraints

- Consumer budget constraint ($I^r_h = E^r_h$)

1. Median voter

$$P^r_L \overline{L}^r_M + P_K \overline{K}^r_M = \sum_i P_{PRI_i} X^r_{M,i} + \sum_j \widetilde{P}^r_{PPQP_j} Q^r_{M,j} + T^r_M \quad [A2.5]$$

where $T^r_M = I^r_M \, t$ if a national tax is used to finance the provision, where

$$t = \frac{\sum_{j,h,r} (P^r_{PPQP_j} - \widetilde{P}^r_{PPQP_j}) Q^r_{M,j} + \sum_r TR^r}{\sum_{h,r} I^r_h}.$$

If regional taxes are used to finance the provision then $T^r_M = I^r_M \, t^r$, where

$$t^r = \frac{\sum_{j,h} (P^r_{PPQP_j} - \tilde{P}^r_{PPQP_j}) Q^r_{h,j} - TR^r}{\sum_h I^r_h}.$$

Notice that in the expressions for t and t^r the summations are over all consumer groups including the median voter.

2. Other consumers

$$P^r_L \overline{L}^r_h + P_K \overline{K}^r_h = \sum_i P_{PRI_i} X^r_{h,i} + \sum_j \tilde{P}^r_{PPQP_j} \overline{Q}^r_{h,j} + T^r_h \,, \; h \neq M \qquad [A2.6]$$

where,

$T^r_h = I^r_h \, t$ or $T^r_h = I^r_h \, t^r$ depending on the financing alternative.

- Provision PPQP goods

$$\overline{Q}^r_{h,j} = Q^r_{M,j} \qquad [A2.7]$$

- Central government budget constraint (I_G=E_G)

$$\sum_{h,r,j} \tilde{P}^r_{PPQP_j} \overline{Q}^r_{h,j} + \sum_{h,r} (P^r_L \overline{L}^r_h + P_K \overline{K}^r_h) t = \sum_{h,r,j} P^r_{PPQP_j} \overline{Q}^r_{h,j} + \sum_r TR^r \qquad [A2.8]$$

- Regional governments budget constraints ($I^r_G = E^r_G$)

$$\sum_{h,j} \tilde{P}^r_{PPQP_j} \overline{Q}^r_{h,j} + \sum_h (P^r_L \overline{L}^r_h + P_K \overline{K}^r_h) t_r + TR^r = \sum_{h,j} P^r_{PPQP_j} \overline{Q}^r_{h,j} \qquad [A2.9]$$

Zero profit conditions

- In each region the value of sales must equal the industries' costs

$$P_{PRI_i} VA^r_{PRI_i} = P^r_L L^r_{PRI_i} + P_K K^r_{PRI_i} \qquad [A2.10]$$

and

$$P^r_{PPQP_j} VA^r_{PPQP_j} = P^r_L L^r_{PPQP_j} + P_K K^r_{PPQP_j} \qquad [A2.11]$$

Market clearing conditions

- Goods markets: gross output must equal final demand:

$$\sum_{r} VA^{r}_{PRI_i} = \sum_{h,r} X^{r}_{h,i} \qquad [A2.12]$$

$$VA^{r}_{PPQP_j} = \sum_{h} Q^{r}_{h,j} \qquad [A2.13]$$

- Labour market

$$\sum_{h} \overline{L}^{r}_{h} = \sum_{i} L^{r}_{PRI_i} + \sum_{j} L^{r}_{PPQP_j} \qquad [A2.14]$$

- Capital market

$$\sum_{h,r} \overline{K}^{r}_{h} = \sum_{i,r} K^{r}_{PRI_i} + \sum_{j,r} K^{r}_{PPQP_j} \qquad [A2.15]$$

Equations for price relationships

- Provision price PPQP goods

$$\tilde{P}^{r}_{PPQP_i} = \phi^{r}\left(\frac{P^{r}_{L} L^{r}_{PPQP_i}}{P^{r^0}_{L} L^{r}_{PPQP_j}}\right), \qquad [A2.16]$$

List of variables

$VA^{r}_{PRI_i}$ Value added PRI good i region r.

$VA^{r}_{PPQP_j}$ Value added PPQP good j region r.

$L^{r}_{PRI_i}$ Labour input PRI good i region r.

$L^{r}_{PPQP_j}$ Labour input PPQP good j region r.

$K^{r}_{PRI_i}$ Capital input PRI good i region r.

$K^r_{PPQP_j}$ Capital input PPQP good j region r.

U^r_h Utility consumer group h region r.

$X^r_{h,i}$ Demand PRI good i consumer group h region r.

$Q^r_{h,j}$ Demand PPQP good j consumer group h region r.

I^r_h Income consumer group h region r.

E^r_h Expenditure consumer group h region r

P^r_L Selling price labour input region r.

P_K Selling price of capital.

P_{PRI_i} Price paid by consumers for PRI good i.

$P^r_{PPQP_j}$ Cost covering price PPQP good j region r.

$\tilde{P}^r_{PPQP_j}$ Price paid by consumers for PPQP good j region r.

T^r_h Income tax paid by consumer group h in region r.

t National income tax rate.

t^r Regional income tax rates.

TR^r Central government transfers regional government r.

List of parameters

γ^r_i Scale parameter value added function, PRI good i region r.

δ^r_i Share parameter value added function, PRI good i region r.

σ^r_i Elasticity of substitution between labour and capital, PRI good i region r.

υ^r_j Elasticity of substitution between labour and capital, PPQP good j region r.

$\alpha^r_{h,i}$ Share parameters utility function, PRI good i region r.

$\alpha^r_{h,j}$ Share parameters utility function, PPQP good j region r.

μ^r_h Elasticity of substitution in consumption consumer group h region r.

$\overline{L}^r_h$ Endowment of labour consumer group h region r.

$\overline{K}^r_h$ Endowment of capital consumer group h region r.

$\overline{Q^r_{h,j}}$ Government provision of PPQP good j to consumer group h region r.

ϕ^r Percentage of the cost of provision of the PPQP goods paid by consumers.

Appendix 2.2: Colombian regional data set

1. Regions

Colombia comprises 33 administrative regions (or provinces). The country is divided in five so-called "natural" or geographic regions, namely Pacific, Atlantic, Andean, Amazonia and Orinoquia. For the central case this regional classification was chosen, although due to data constraints, Amazonia, and Orinoquia (henceforth A&O) are considered as one region.[11] The Andean region accounts for 63% of GDP, whereas the Pacific region accounts for 15% of GDP, the Atlantic region accounts for 15.1% of GDP, and the A&O region for 6.9% of GDP.

Table A2.1: Regional classification

Andean Region	Antioquia	Boyacá	Caldas
	Cundinamarca	Huila	Norte de Santander
	Quindío	Risaralda	Santafé de Bogotá, D.C.
	Santander	Tolima	
Atlantic Region	Atlántico	Bolívar	Cesar
	Córdoba	La Guajira	Magdalena
	Sucre		
Pacific Region	Cauca	Chocó	Nariño
	Valle del Cauca		
Amazonia and Orinoquia	Caquetá	Meta	Nuevos Departamentos [1/]

[1/] Nuevos Departamentos includes Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, the archipelago of San Andrés, Providencia and Santa Catalina, Vaupés, and Vichada.

[11] In the Colombian regional accounts (DANE, 1995b) there is a region labelled "Nuevos Departamentos" which comprises nine provinces, since DANE does not publish production accounts for each province individually. These regions correspond to those located in the Amazonia and Orinoquia.

Further, regional GDP figures for 1992 (as taken from DANE (1995b)) were used to divide the country into three regions, each consisting of eleven provinces (see Table A.2.2). The group Nuevos Departamentos was included in region one because it comprises the country's less developed provinces. Region two comprises the following 11 provinces, and region three includes the province with the highest GDP, which are perhaps the most developed regions of the country. According to this classification, regions one, two and three account for 5%, 18%, and 77%, respectively.

Table A2.2: Regional classification according to GDP

Provinces	GDP Col$ millions	Provinces	GDP Col$ millions
Region 1	1,712,862	Region 3	25,839,993
Chocó	138,477	Huila	726,300
Caquetá	153,278	Risaralda	795,891
Nuevos Departamentos [1/]	1,421,107	Boyacá	952,630
		Tolima	1,000,601
Region 2	5,962,191	Bolívar	1,325,716
		Atlántico	1,373,130
Sucre	252,685	Santander	1,710,033
Cesar	431,442	Cundinamarca	2,041,178
Nariño	501,919	Valle del Cauca	3,893,867
Quindío	514,415	Antioquia	4,872,343
Magdalena	543,083	Santafé de Bogotá, D.C.	7,148,304
La Guajira	547,622		
Cauca	553,303		
Norte de Santander	587,561		
Meta	644,714		
Córdoba	669,114		
Caldas	716,333		

Total GDP is Col$33,515,046 millions.
[1/] Includes Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, the archipelago of San Andrés, Providencia and Santa Catalina, Vaupés, and Vichada.
Source: DANE (1995b).

Lastly, regional agricultural GDP figures for 1992 were used to divide the country in five regions. The resulting classification is presented in Table A.2.3. This

table reveals that region one accounts for approximately 4% of total agricultural GDP, region two for 7%, region three for 17%, region four for 21%, and region five for 51%.

Table A2.3: Regional classification according to Agricultural GDP

Provinces	Agricultural GDP Col$ millions	Provinces	Agricultural GDP Col$ millions
Region 1	193,111	Region 4	1,107,697
Nuevos Departamentos [1/]	193,111	Nariño	166,432
		Boyacá	168,425
Region 2	352,457	Bolívar	183,950
		Magdalena	188,838
Santafé de Bogotá, D.C.	2,874	Caldas	192,412
Chocó	37,457	Cesar	207,640
La Guajira	39,683		
Caquetá	68,443	Region 5	2,660,202
Atlántico	90,411		
Sucre	113,589	Córdoba	248,265
		Tolima	303,623
Region 3	874,927	Santander	330,717
		Valle del Cauca	559,169
Norte de Santander	118,052	Antioquia	593,014
Huila	139,493	Cundinamarca	625,414
Quindío	142,768		
Meta	152,673		
Risaralda	157,717		
Cauca	164,224		

Total agricultural GDP is Col$5,188,394 millions.
[1/] Includes Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, the archipelago of San Andrés, Providencia and Santa Catalina, Vaupés, and Vichada.
Source: This information was kindly provided by Hector Mejía from DANE.

2. Production and factors of production

In the model, each region is assumed to produce three PRI goods and two PPQP goods. The formers are allocated by the market according to supply and demand conditions, whereas the latter are provided by the government.

The Colombian national accounts classifies products, based on the international standard industrial classification (ISIC) of the United Nations, in nine broad categories: agriculture, fishing and hunting; mining; manufacturing; electricity, gas and water; construction; transportation and storage; communications; personal and business services; and government services. The first eight categories (which account for 89.8% of GDP) are considered as private goods. Then, these goods were classified into primary commodities (including fuels), manufactured goods, and services. PPQP goods are included in the ninth category (which represents 10.2% of GDP). Using the Colombian SAM for 1992 (Valderrama and Gutiérrez, 1996) it was possible to disaggregate government services into health, education, and other government services: health accounts for approximately 2.3% of GDP, and education for 0.4% of GDP. Other government services were added to services.

The value added generated by each administrative region is obtained from the Colombian regional accounts (DANE, 1995b). Value added comprises payments to labour, net indirect taxes, and operating surplus, the latter obtained as a residual. From DANE (1995b) it is not possible to break down regional value added into its components. However, national accounts (DANE, 1995a) allows us to determine the composition of value added at the national level. Therefore, using national accounts data the value-added share of payments to labour, operating surplus, and net indirect taxes for each of the nine categories considered by the national accounts were calculated. The resulting shares are used at the regional level to disaggregate value

added into its components. Using these shares it is possible to know the endowment of labour and capital in each region. Table A2.4 presents the resulting regional factor endowments.

Table A2.4: Regional value added at factor cost
Col$ billions

Regions	Labour	Capital	Total
Pacific region	2,077.3	2,464.2	4,541.5
Atlantic region	1,944.8	2,633.4	4,578.2
Andean region	8,771.5	10,293.5	19,065.0
A&O region	689.7	1,405.2	2,094.9
Total	13,483.3	16,796.3	30,279.6

Source: Author's calculations.

When the country is divided into three regions using GDP, the corresponding regional factor endowments are:

Regions	Labour	Capital	Total
Region 1	518.3	1,100.5	1,618.8
Region 2	2,421.6	3,147.4	5,569.0
Region 3	10,543.4	12,548.4	23,091.8
Total	13,483.3	16,796.3	30,279.6

Source: Author's calculations.

And, when the country is divided into five regions using agricultural GDP, the regional factor endowments are:

Regions	Labour	Capital	Total
Region 1	380.0	960.7	1,340.7
Region 2	4,180.0	4,542.9	8,722.9
Region 3	1,539.4	1,986.0	3,525.4
Region 4	1,804.4	2,223.5	4,027.9
Region 5	5,579.5	7,083.2	12,662.7
Total	13,483.3	16,796.3	30,279.6

Source: Author's calculations.

Since the tax structure of the country is not being considered, net indirect taxes are deducted from regional value added, so that value added at factor cost is obtained.

3. Demand

The model considers three groups of consumers per region: low, medium, and high-income groups. The first group comprises the bottom four deciles of the population; the second group includes the following four deciles; and the third group comprises the top two deciles of the population. The Social Accounting Matrix for 1992 assembled for Colombia by Valderrama and Gutiérrez (1996) was used to calculate each group's consumption of the PRI and PPQP goods. For the Pacific, Atlantic and Andean regions the percentages of consumption of each good are calculated using national totals (includes both urban and rural consumption); the resulting percentages are:

	Consumer group1	Consumer group 2	Consumer group 3
Primary commodities	24.0%	43.0%	33.0%
Manufactured goods	23.6%	40.0%	36.4%
Services	13.3%	35.1%	51.6%
Health	13.6%	33.2%	53.2%
Education	13.6%	33.2%	53.2%

For the A&O region, information for rural consumers was used, and the percentages of consumption are:

	Consumer group1	Consumer group 2	Consumer group 3
Primary Commodities	24.0%	44.1%	31.9%
Manufactured goods	22.1%	42.6%	35.3%
Services	13.5%	33.5%	53.0%
Health	15.8%	33.4%	50.8%
Education	15.8%	33.4%	50.8%

Given that there is no information about regional consumption, the proportions presented above were used to calculate the regional consumption of each good.

In the model the PPQP goods are regarded as non-tradable; hence, regional production equals regional consumption. As to the PRI goods, there is no initial interregional trade, and there are no transfers to consumers.

Consumers are the owners of the factors of production. However, given that there is no information about regional factor ownership, the national capital-labour ratio is assumed for all consumers in the region. The resulting four-region data set is presented in Tables 2.1 in the text. The data sets for three and five regions are reported in tables A2.5 and A2.6.

Table A.2.5: Colombian regional data set
Regional classification according to GDP
(Col$ billion)

Production side: Primary inputs

	Region 1			Region 2			Region 3			Total
	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Value Added
Primary goods	227.8	820.4	1,048.3	794.8	1,505.0	2,299.7	1,415.6	2,552.0	3,967.6	7,315.6
Manufactures	6.2	7.0	13.2	223.0	252.5	475.5	2,096.9	2,374.8	4,471.7	4,960.3
Services	250.2	273.0	523.2	1,244.6	1,390.0	2,634.6	6,346.5	7,621.6	13,968.1	17,125.9
Education										
Region 1	4.9	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	4.9
Region 2	0.0	0.0	0.0	23.0	0.0	23.0	0.0	0.0	0.0	23.0
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	98.8	0.0	98.8	98.8
Health										
Region 1	29.2	0.0	29.2	0.0	0.0	0.0	0.0	0.0	0.0	29.2
Region 2	0.0	0.0	0.0	136.2	0.0	136.2	0.0	0.0	0.0	136.2
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	585.7	0.0	585.7	585.7
Total	518.3	1,100.5	1,618.8	2,421.6	3,147.4	5,569.0	10,543.4	12,548.4	23,091.8	30,279.6

Demand side: Final demands

	Region 1			Region 2			Region 3			
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Total
Primary goods	251.2	450.7	346.3	551.1	988.8	759.8	950.8	1,706.0	1,310.8	7,315.6
Manufactures	3.1	5.3	4.8	112.4	190.0	173.1	1,057.0	1,786.8	1,627.8	4,960.3
Services	69.6	183.7	269.9	350.6	925.0	1,358.9	1,859.0	4,904.4	7,204.6	17,125.9
Education										
Region 1	0.7	1.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0	4.9
Region 2	0.0	0.0	0.0	3.1	7.6	12.2	0.0	0.0	0.0	23.0
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	13.4	32.9	52.5	98.8
Health										
Region 1	4.0	9.7	15.5	0.0	0.0	0.0	0.0	0.0	0.0	29.2
Region 2	0.0	0.0	0.0	18.5	45.3	72.4	0.0	0.0	0.0	136.2
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	79.5	194.7	311.4	585.7
Total	328.6	651.1	639.1	1,035.8	2,156.8	2,376.4	3,959.8	8,624.8	10,507.2	30,279.6

Consumers income and expenditure accounts

	Region 1			Region 2			Region 3			
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Total
Income:										
Labour income	105.2	208.5	204.7	450.4	937.9	1,033.4	1,808.0	3,938.0	4,797.4	13,483.3
Capital income	223.4	442.6	434.5	585.4	1,219.0	1,343.1	2,151.8	4,686.8	5,709.8	16,796.3
Total income	328.6	651.1	639.1	1,035.8	2,156.8	2,376.4	3,959.8	8,624.8	10,507.2	30,279.6
Expenditure:										
Final demand	328.6	651.1	639.1	1,035.8	2,156.8	2,376.4	3,959.8	8,624.8	10,507.2	30,279.6
Taxes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total expenditure	328.6	651.1	639.1	1,035.8	2,156.8	2,376.4	3,959.8	8,624.8	10,507.2	30,279.6

Government income and expenditure accounts

Income:	
Provision Education	126.7
Provision Health	751.1
Tax collections	0.0
Total income	877.8
Expenditure:	
Cost provision Educ	126.7
Cost provision Healt	751.1
Total expenditure	877.8

Source: DANE (1995b) and author's calculations.

Table A.2.6: Colombian regional data set
Regional classification according to agricultural GDP
(Col$ billion)

Production side: Primary inputs

	Region 1			Region 2			Region 3			Region 4			Region 5			Total
	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Labour	Capital	Value Added	Value Added
Primary goods	180.1	733.2	913.3	188.2	471.0	659.2	404.4	781.0	1,185.5	488.6	843.7	1,332.3	1,176.9	2,048.5	3,225.4	7,315.6
Manufactures	1.7	1.9	3.6	751.7	851.3	1,603.0	220.4	249.6	470.1	249.5	282.6	532.1	1,102.7	1,248.9	2,351.6	4,960.3
Services	180.5	225.6	406.1	2,875.2	3,220.6	6,095.8	819.1	955.3	1,774.4	951.6	1,097.2	2,048.7	3,015.0	3,785.9	6,800.8	17,125.9
Education																
Region 1	2.6	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Region 2	0.0	0.0	0.0	52.7	0.0	52.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.7
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0	13.8	0.0	0.0	0.0	0.0	0.0	0.0	13.8
Region 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.6	0.0	16.6	0.0	0.0	0.0	16.6
Region 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.1	0.0	41.1	41.1
Health																
Region 1	15.2	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
Region 2	0.0	0.0	0.0	312.3	0.0	312.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	312.3
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	81.6	0.0	81.6	0.0	0.0	0.0	0.0	0.0	0.0	81.6
Region 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.2	0.0	98.2	0.0	0.0	0.0	98.2
Region 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	243.7	0.0	243.7	243.7
Total	380.0	960.7	1,340.7	4,180.1	4,542.9	8,723.0	1,539.4	1,986.0	3,525.4	1,804.4	2,223.5	4,027.9	5,579.5	7,083.2	12,662.7	30,279.6

Demand side: Final demands

	Region 1			Region 2			Region 3			Region 4			Region 5			Total
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	
Primary goods	218.9	392.7	301.7	158.0	283.4	217.8	284.1	509.7	391.7	319.3	572.9	440.2	772.9	1,386.8	1,065.6	7,315.6
Manufactures	0.8	1.4	1.3	378.9	680.5	583.5	111.1	187.8	171.1	125.8	212.6	193.7	555.9	939.7	856.1	4,960.3
Services	54.0	142.6	209.5	811.3	2,140.3	3,144.2	236.2	623.0	915.2	272.7	719.3	1,056.7	905.1	2,387.9	3,507.8	17,125.9
Education																
Region 1	0.3	0.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Region 2	0.0	0.0	0.0	7.2	17.5	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.7
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	1.9	4.6	7.3	0.0	0.0	0.0	0.0	0.0	0.0	13.8
Region 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	5.5	8.8	0.0	0.0	0.0	16.6
Region 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	13.7	21.9	41.1
Health																
Region 1	2.1	5.1	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
Region 2	0.0	0.0	0.0	42.4	103.8	166.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	312.3
Region 3	0.0	0.0	0.0	0.0	0.0	0.0	11.1	27.1	43.4	0.0	0.0	0.0	0.0	0.0	0.0	81.6
Region 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	32.7	52.2	0.0	0.0	0.0	98.2
Region 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.1	81.0	129.6	243.7
Total	276.2	542.6	521.9	1,397.8	3,185.7	4,139.6	644.3	1,352.3	1,528.7	733.3	1,543.0	1,751.6	2,272.6	4,809.1	5,580.9	30,279.6

Consumers income and expenditure accounts

	Region 1			Region 2			Region 3			Region 4			Region 5			Total
	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	Cons. 1	Cons. 2	Cons.3	
Income:																
Labour income	78.3	153.8	147.9	669.8	1,526.6	1,983.7	281.3	590.5	667.5	328.5	691.2	784.7	1,001.4	2,119.0	2,459.1	13,483.3
Capital income	197.9	388.8	374.0	727.9	1,659.1	2,155.9	363.0	761.8	861.2	404.8	851.8	966.9	1,271.3	2,690.1	3,121.9	16,796.3
Total income	276.2	542.6	521.9	1,397.8	3,185.7	4,139.6	644.3	1,352.3	1,528.7	733.3	1,543.0	1,751.6	2,272.6	4,809.1	5,580.9	30,279.6
Expenditure:																
Final demand	276.2	542.6	521.9	1,397.8	3,185.7	4,139.6	644.3	1,352.3	1,528.7	733.3	1,543.0	1,751.6	2,272.6	4,809.1	5,580.9	30,279.6
Taxes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total expenditure	276.2	542.6	521.9	1,397.8	3,185.7	4,139.6	644.3	1,352.3	1,528.7	733.3	1,543.0	1,751.6	2,272.6	4,809.1	5,580.9	30,279.6

Government income and expenditure accounts

Income:	
Provision Education	126.7
Provision Health	751.1
Tax collections	0.0
Total income	877.8
Expenditure:	
Cost provision Educ	126.7
Cost provision Healt	751.1
Total expenditure	877.8

Source: DANE (1995b) and author's calculations.

Appendix 2.3

Quantities of education and health provided by
the central and regional governments as determined by the median voter

Table A2.3.1: Regional classification according to geographic regions
(billion units)

Percentage of The cost of Provision paid by consumers (PP):	Education	Health
1. *National provision financed with a national tax*		
PP = 80%	5.4	31.8
PP = 50%	5.9	35.2
PP = 30%	6.4	37.9
PP = 0%	7.2	42.8
2. *National provision financed with regional taxes*		
PP = 80%	4.9	29.0
PP = 50%	4.7	27.7
PP = 30%	4.6	27.0
PP = 0%	4.4	25.9
3. *National provision financed with regional taxes and a 0.05% national tax*		
PP = 80%	4.9	29.0
PP = 50%	4.7	27.7
PP = 30%	4.5	27.0
PP = 0%	4.4	25.9

Table A2.3.1 (Continued): Regional classification according to geographic regions (billion units)

Percentage of the cost of provision paid by consumers:	Region 1		Region 2		Region 3		Region 4	
	Educ.	Health	Educ.	Health	Educ.	Health	Educ.	Health
1. *Regional provision financed with a national tax*								
PP = 80%	6.9	40.6	6.0	35.6	31.4	186.0	2.2	12.9
PP = 50%	9.8	57.6	8.6	50.4	34.6	204.9	3.3	19.3
PP = 30%	13.7	80.1	11.9	69.8	37.2	219.8	5.0	29.1
PP = 0%	33.8	196.5	28.8	168.0	41.8	246.8	21.4	124.6
2. *Regional provision financed with regional taxes*								
PP = 80%	5.6	33.2	4.9	29.0	28.9	171.1	1.7	10.2
PP = 50%	5.4	32.0	4.7	27.7	27.9	165.2	1.6	9.6
PP = 30%	5.3	31.2	4.6	27.0	27.3	161.5	1.6	9.3
PP = 0%	5.1	30.1	4.4	25.9	26.4	156.3	1.5	8.8
3. *Regional provision financed with regional taxes and a 0.05% national tax*								
PP = 80%	5.6	33.2	4.9	29.0	28.9	171.0	1.7	10.2
PP = 50%	5.4	31.9	4.7	27.7	27.9	165.1	1.6	9.6
PP = 30%	5.3	31.2	4.5	27.0	27.2	161.5	1.6	9.3
PP = 0%	5.1	30.1	4.4	25.9	26.4	156.2	1.5	8.8

Note: In some cases the provision levels seem identical, but this is due to rounding.

Table A2.3.2: Regional classification according to regional GDP (billion units)

Percentage of the cost of provision paid by consumers (PP):	Education	Health
1. *National provision financed with a national tax*		
PP = 80%	8.2	48.8
PP = 50%	9.3	55.2
PP = 30%	10.2	60.5
PP = 0%	11.9	70.7
2. *National provision financed with regional taxes*		
PP = 80%	7.4	43.9
PP = 50%	7.1	41.9
PP = 30%	6.9	40.7
PP = 0%	6.6	39.0
3. *National provision financed with regional taxes and a 0.05% national tax*		
PP = 80%	7.4	43.9
PP = 50%	7.1	41.9
PP = 30%	6.9	40.7
PP = 0%	6.6	39.0

Table A2.3.2 (Continued): Regional classification according to regional GDP (billion units)

Percentage of the cost of provision paid by consumers:	Region 1		Region 2		Region 3	
	Educ.	Health	Educ.	Health	Educ.	Health
1. *Regional provision financed with a national tax*						
PP = 80%	2.0	11.9	9.1	53.5	33.8	200.4
PP = 50%	3.1	18.0	12.6	73.9	35.4	209.7
PP = 30%	4.7	27.6	17.0	99.4	36.6	216.4
PP = 0%	25.2	146.7	35.6	207.8	38.4	227.2
2. *Regional provision financed with regional taxes*						
PP = 80%	1.6	9.3	7.4	43.9	32.1	190.1
PP = 50%	1.5	8.8	7.1	41.9	31.0	183.7
PP = 30%	1.4	8.5	6.9	40.7	30.3	179.6
PP = 0%	1.4	8.0	6.6	39.0	29.3	173.8
3. *Regional provision financed with regional taxes and a 0.05% national tax*						
PP = 80%	1.6	9.3	7.4	43.9	32.1	190.0
PP = 50%	1.5	8.8	7.1	41.9	31.0	183.6
PP = 30%	1.4	8.5	6.9	40.7	30.3	179.5
PP = 0%	1.4	8.0	6.6	39.0	29.3	173.7

Note: In some cases the provision levels seem identical, but this is due to rounding.

Table A2.3.3: Regional classification according to agricultural GDP (billion units)

Percentage of the cost of provision paid by consumers (PP):	Education	Health
1. *National provision financed with a national tax*		
PP = 80%	5.4	32.3
PP = 50%	5.3	31.1
PP = 30%	5.1	30.4
PP = 0%	5.0	29.4
2. *National provision financed with regional taxes*		
PP = 80%	6.2	36.5
PP = 50%	7.3	43.0
PP = 30%	8.2	48.9
PP = 0%	10.4	61.5
3. *National provision financed with regional taxes and a 0.05% national tax*		
PP = 80%	6.1	36.4
PP = 50%	7.3	43.0
PP = 30%	8.2	48.9
PP = 0%	10.4	61.4

Table A2.3.3 (Continued): Regional classification according to agricultural GDP (billion units)

Percentage of the cost of provision paid by consumers (PP):	Region 1		Region 2		Region 3		Region 4		Region 5	
	Educ.	Health	Educ.	Health	Educ.	Health	Educ.	Health	Educ.	Health
1. *Regional provision financed with a national tax*										
PP = 80%	1.1	6.2	20.3	120.0	5.5	32.7	6.6	39.2	15.3	90.2
PP = 50%	1.6	9.5	26.6	156.7	8.1	47.5	9.5	56.2	18.5	108.9
PP = 30%	2.5	14.7	33.6	197.4	11.6	68.1	13.5	79.4	21.5	126.5
PP = 0%	15.8	91.7	55.4	324.3	34.1	199.3	35.9	210.3	28.6	167.5
2. *Regional provision financed with regional taxes*										
PP = 80%	0.8	4.8	17.2	101.9	4.4	26.3	5.3	31.7	13.3	78.8
PP = 50%	0.8	4.6	16.7	99.1	4.3	25.2	5.1	30.4	12.8	75.8
PP = 30%	0.7	4.4	16.4	97.3	4.1	24.5	5.0	29.6	12.5	73.8
PP = 0%	0.7	4.2	16.0	94.8	4.0	23.6	4.8	28.4	12.0	71.1
3. *Regional provision financed with regional taxes and a 0.05% national tax*										
PP = 80%	0.8	4.8	17.2	101.8	4.4	26.3	5.3	31.7	13.3	78.8
PP = 50%	0.8	4.6	16.7	99.1	4.3	25.2	5.1	30.4	12.8	75.7
PP = 30%	0.7	4.4	16.4	97.3	4.1	24.5	5.0	29.5	12.4	73.8
PP = 0%	0.7	4.2	16.0	94.7	4.0	23.6	4.8	28.4	12.0	71.1

Note: In some cases the provision levels seem identical, but this is due to rounding.

Appendix 2.4: Empirical implementation using Colombian data

Tax rates when consumers pay 0% of the cost of provision

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific	1.9%	2.0%	1.9%
Atlantic	1.9%	2.0%	1.9%
Andean	1.9%	0.5%	0.5%
A&O	1.9%	4.3%	4.2%
Regional provision			
Pacific	10.2%	2.3%	2.2%
Atlantic	10.2%	2.0%	1.9%
Andean	10.2%	2.9%	2.9%
A&O	10.2%	1.5%	1.3%

Subsidies when consumers pay 0% of the cost of provision
(Col $ billion)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific			
Consumer 1	34.6	14.3	14.6
Consumer 2	16.9	-3.9	-3.4
Consumer 3	10.7	-10.4.	-9.7
Atlantic			
Consumer 1	32.2	13.5	13.8
Consumer 2	14.6	-4.6	-4.1
Consumer 3	10.5	-8.9	-8.3
Andean			
Consumer 1	-13.2	14.7	13.7
Consumer 2	-87.9	-3.7	-5.8
Consumer 3	-117.9	-11.0	-13.7
A&O			
Consumer 1	38.4	12.1	12.6
Consumer 2	30.4	-6.1	-5.0
Consumer 3	30.5	-6.0	-4.9
Regional provision			
Pacific			
Consumer 1	152.8	16.7	16.9
Consumer 2	64.0	-4.6	-4.0
Consumer 3	32.5	-12.1	-11.4
Atlantic			
Consumer 1	172.1	13.5	13.8
Consumer 2	-69.1	-4.6	-4.1
Consumer 3	-44.9	-8.9	-8.3
Andean			
Consumer 1	-29.3	88.8	87.7
Consumer 2	-404.4	-22.2	-24.3
Consumer 3	-554.7	-66.6	-69.2
A&O			
Consumer 1	183.3	4.1	4.7
Consumer 2	134.6	-2.1	-1.0
Consumer 3	135.1	-2.0	-0.9

Note: The subsidy is calculated as the cost of provision of the PPQP goods, minus the value paid by the consumer and the income tax.

Tax rates when consumers pay 30% of the cost of provision

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific	1.2%	1.5%	1.4%
Atlantic	1.2%	1.4%	1.4%
Andean	1.2%	0.3%	0.3%
A&O	1.2%	3.2%	3.0%
Regional provision			
Pacific	3.3%	1.7%	1.6%
Atlantic	3.3%	1.4%	1.4%
Andean	3.3%	2.1%	2.1%
A&O	3.3%	1.1%	0.9%

Subsidies when consumers pay 30% of the cost of provision
(Col $ billion)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific			
Consumer 1	21.5	10.5	10.7
Consumer 2	10.7	-2.9	-2.3
Consumer 3	6.8	-7.6	-6.9
Atlantic			
Consumer 1	19.5	9.9	10.1
Consumer 2	8.9	-3.4	-2.8
Consumer 3	6.4	-6.5	-5.8
Andean			
Consumer 1	-7.8	10.7	9.7
Consumer 2	-53.6	-2.7	-4.8
Consumer 3	-72.0	-8.0	-10.6
A&O			
Consumer 1	23.1	8.8	9.3
Consumer 2	18.2	-4.5	-3.4
Consumer 3	18.3	-4.3	-3.2
Regional provision			
Pacific			
Consumer 1	39.9	12.1	12.4
Consumer 2	10.3	-3.3	-2.7
Consumer 3	-0.2	-8.8	-8.1
Atlantic			
Consumer 1	29.7	9.9	10.1
Consumer 2	0.2	-3.4	-2.8
Consumer 3	-6.8	-6.5	-5.8
Andean			
Consumer 1	74.2	64.2	63.2
Consumer 2	-50.6	-16.0	-18.2
Consumer 3	-100.7	-48.2	-50.9
A&O			
Consumer 1	10.3	3.0	3.6
Consumer 2	-3.2	-1.5	-0.4
Consumer 3	-3.1	-1.5	-0.4

Note: The subsidy is calculated as the cost of provision of the PPQP goods, minus the value paid by the consumer and the income tax.

Tax rates when consumers pay 80% of the cost of provision

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific	0.3%	0.4%	0.4%
Atlantic	0.3%	0.4%	0.4%
Andean	0.3%	0.1%	0.1%
A&O	0.3%	1.0%	0.8%
Regional provision			
Pacific	0.6%	0.5%	0.4%
Atlantic	0.6%	0.4%	0.4%
Andean	0.6%	0.6%	0.6%
A&O	0.6%	0.3%	0.2%

Subsidies when consumers pay 80% of the cost of provision
(Col $ billion)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
National provision			
Pacific			
Consumer 1	5.2	3.2	3.5
Consumer 2	2.6	-0.9	-0.3
Consumer 3	1.7	-2.3.	-1.7
Atlantic			
Consumer 1	4.6	3.0	3.3
Consumer 2	2.1	-1.0	-0.5
Consumer 3	1.5	-2.0	-1.3
Andean			
Consumer 1	-1.8	3.3	2.3
Consumer 2	-12.6	-0.8	-3.0
Consumer 3	-17.0	-2.5	-5.0
A&O			
Consumer 1	5.3	2.7	3.2
Consumer 2	4.2	-1.4	-0.3
Consumer 3	4.2	-1.3	-0.2

Note: The subsidy is calculated as the cost of provision of the PPQP goods, minus the value paid by the consumer and the income tax.

Subsidies when consumers pay 80% of the cost of provision
(Col $ billion)

	Provision financed by:		
	National tax	Regional taxes	Regional taxes and national tax of 0.05%
Regional provision			
Pacific			
Consumer 1	4.4	3.7	3.9
Consumer 2	-1.4	-1.0.	-0.4
Consumer 3	-3.5	-2.7	-2.0
Atlantic			
Consumer 1	3.0	3.0	3.3
Consumer 2	-2.9	-1.0	-0.5
Consumer 3	-4.3	-2.0	-1.3
Andean			
Consumer 1	22.7	19.4	18.4
Consumer 2	-1.9	-4.8	-7.0
Consumer 3	-11.8	-14.6	-17.1
A&O			
Consumer 1	0.3	0.9	1.5
Consumer 2	-2.3	-0.5	0.6
Consumer 3	-2.3	-0.4	0.6

Note: The subsidy is calculated as the cost of provision of the PPQP goods, minus the value paid by the consumer and the income tax.

CHAPTER 3

TAX EXPORTING:

AN ANALYSIS USING A MULTIREGIONAL CGE MODEL

3.1 INTRODUCTION

The purpose of this chapter is to evaluate whether developed countries export taxes to developing countries, contributing to the deterioration of their terms of trade and welfare. Developing countries have become increasingly integrated into world commerce. Since the beginning of the 1990's most developing countries have undertaken radical changes in their trade regimes. Trade negotiations have mainly concentrated on multilateral tariff reductions and in giving preferential treatment to developing countries, and hence helping them to improve their welfare. However, so far the role of domestic taxation in affecting the distribution of gains from trade, has been overlooked. Hence, the purpose of this chapter is to investigate whether the distribution of gains from trade is being affected not by existing tariffs in developed countries, which are already at low levels, but by their domestic taxation.

Toward this end, a computable general equilibrium (CGE) model for the world economy is built. This modelling approach constitutes an appropriate tool for this analysis, since it allows us to model the interrelationships between different regions. The model consists of eight regions: the United States (USA), Japan (JAP), the European Union (EU), other developed countries (ODC), developing America (DAM), developing Africa (DAF), developing Asia (DAS), and developing Europe (DE). Each region has a production and demand structure, and are linked through

trade. Further, the model explicitly includes domestic taxation and commercial policy. Domestic taxation comprises taxes such as corporate tax, property tax, payroll tax, social security contributions, income tax, and a tax on final expenditure. Commercial policy is represented by import tariffs. The model uses data for 1990.

To the best of my knowledge, the issue of tax exporting among countries has not been analysed empirically, although Mutti and Morgan (1986), and Morgan et al (1996) have looked at tax exporting among regions within the same country (the United States). One of the few analyses in this area is that of Whalley (1980a), who investigates the strength of relative price effects in international trade caused by the different domestic factor taxes which operate in the United States, the European Union, and Japan. Whalley uses a four-region general equilibrium model (the fourth region being the rest of the world), which incorporates tariffs, non-tariff barriers and domestic taxation policies of major trading blocks, using data for 1973. This author finds that domestic factor taxes can induce very strong terms of trade effects and that, for some trading areas, domestic taxation can be more important in distorting international trade than traditional instruments of commercial policy, such as import tariffs.[1]

My study differs in one important respect from Whalley (1980a). There is a distinction between developed and developing regions, and more importantly both groups have been divided further into four sub-groups. The advantage of this additional disaggregation is that it helps to identify from which region(s) developing sub-groups are likely to import taxes. Developed regions have more commercial ties with some particular developing regions than with others, and so their domestic tax

[1] See Whalley (1984) for an analysis of the role of trade protection policies on the North-South terms of trade.

policies may affect one developing region more than another. It is worth mentioning that developed countries main trading partners are developed countries themselves, and this inter-developed regions trade may weaken tax exporting effects. In 1990, for example, 65% of the United States exports were destined to Japan, the European Union and other developed countries, whereas less than 16% were destined to developing America and developing Africa (these figures are taken from the benchmark data set).

According to the results, when factors of production are internationally immobile, developed regions do not export factor taxes to developing regions because the burden of the tax is borne by the immobile factors. By contrast, when capital is internationally mobile the replacement of capital taxes in developed regions generates welfare gains and terms of trade improvement in developing countries. In this case, the replacement of the tax reduces the return to capital, as this factor moves into developed regions, and this in turn reduces the cost of producing exports (i.e. developing countries imports are cheaper). This result suggests that developed countries were exporting capital taxes to developing regions. In addition, it is found that JAP exports income taxes to developing regions, although the effects on welfare and terms of trade are small. Regardless of the assumptions on international capital mobility, the effects of import tariffs on welfare and terms of trade are larger than those of domestic taxes.

The outline of the chapter is as follows. Section 2 briefly presents the theoretical underpinnings of the study. Section 3 describes the structure of the multiregional computable general equilibrium model used in the analysis of tax exporting. Section 4 presents the empirical implementation, which involves the construction of an eight-region benchmark data set as well as the specification of

elasticities. Section 5 summarises the results of the model, for the cases of factor immobility, international capital mobility, differential factor taxation, and also presents the sensitivity analysis. Concluding remarks are offered in section 6.

3.2 THEORETICAL UNDERPINNINGS OF THE STUDY

Tax exporting refers to the shifting of tax burdens from domestic residents to non-residents of the taxing jurisdiction; it is also known in the theory of international trade as the terms of trade effect (see e.g. Dixit and Norman, 1980; Woodland, 1982; Krugman and Obstfeld, 1994; Bhagwati et al, 1998).

To illustrate this concept, let us consider the case of a country that imposes a tariff on imports of a good in whose market the country has some market power. In this case, the effect of the imposition of a tariff will be to raise the price in the home country while lowering the price in the exporting country. As a result, the volume of trade in the world market falls. The increase in the price in the home country is less than the amount of the tariff, because part of the tariff is reflected in a reduction in the other country's export price, and hence is not passed on to domestic consumers. This decline in the foreign country's export price will improve the home country's terms of trade, leading to a welfare improvement in the home economy.

A country can improve its terms of trade by imposing a tariff but at the cost of increased inefficiencies. First, there is a production distortion loss, caused by the increase in domestic production of the good as a result of the higher domestic price. Second, there is a consumption distortion loss caused by the reduction in consumers' demand for the good, once again as a result of the higher domestic price. The benefits of the tariffs are represented by the terms of trade gain resulting from the decline in the foreign export price. The final result in terms of welfare will depend on which

effect dominates. In a country that can not affect its terms of trade, costs will exceed benefits.

The existing literature on tax exporting has concentrated in the exportation of state and local taxes to other regions within the same country. This literature has also focused on issues such as foreign tax credits (e.g. Damus et al, 1991) and deductibility of state and local taxes with multilevel governments (e.g. Wildasin, 1987a).

McLure (1969) is one of the first authors that analysed tax exporting in the context of a general equilibrium framework.[2] McLure addressed the question of the extent to which the burden of taxes levied by state and local governments is borne by non-residents of the taxing jurisdiction. In order to do this, he presented a theoretical general equilibrium analysis of interstate incidence of several types of general taxes levied in one state in a larger nation.[3] The key assumption in McLure's analysis is that labour is completely immobile between states; also, capital is assumed to be perfectly mobile in response to interstate differentials in rates of return, and the geographic site of residence of both workers and capitalists is assumed to be fixed. McLure concludes that, under the restrictive assumptions of his model, "...the degree of net tax exporting on the side of sources of income depends upon the change in the return to capital resulting from the tax in question and the extent to which the non-taxing state is a net debtor or creditor" (p. 481). On the uses side, "...interstate tax exporting depends upon how the tax alters the terms or trade of the non-taxing state and the amount of the product of the taxing state bought by non-residents" (p. 482).

---

[2] In this case, the general equilibrium framework matters because the author is considering interstate mobility of factors, and this assumption is likely to be of considerable importance in determining interstate tax incidence.

[3] These general taxes include: taxes on all labour employed in the taxing state, on all capital invested in the state, on all production of the state, on the consumption of all domestically produced goods, on all imports, and on all exports.

This kind of tax exporting can be significant when the regions' producers and/or consumers are non-negligible in size relative to the market for some particular commodity (a good or a factor). In this case, the government will have an incentive to tax exports or imports in order to restrict trade and to achieve improvements in the region's terms of trade. Oates (1972) points out that a common form of tax exporting could be the imposition of a tax on restaurants and hotel bills in tourist centres.

One implication of tax exporting is that it is commonly believed that the presence of tax exporting reduces the effective cost of public services, by pushing some of the burden on to non-residents, and thus creating an incentive to increase public expenditure. This issue has been analysed by Wildasin (1987b), who shows that the additional revenues could be collected from exported or non-exported taxes without affecting the marginal cost of public funds. Furthermore, Wildasin (1987a) points out that if tax exporting affects spending, it will do so by creating an income effect and by affecting the marginal excess burden of non-exported taxes.

In a paper evaluating the literature on interregional exporting and importing of state and local taxes within the United States, Mutti and Morgan (1986) indicate that tax exporting may result in lower tax rates since public services could be partly financed by non-residents. In the long run tax exporting can also have effects on the levels of income and employment within the taxing region, in the patterns of resource use and on the location of economic activity across regions, since the lower tax rates may attract footloose industries and other mobile factors to the region. The inflow of factors can result in rapid growth of the tax-exporting region (see for example, Oates, 1972; Mutti and Morgan, 1986; Oates, 1991).

Little empirical work has been done on tax exporting among countries. Damus et al (1991) evaluate tax exporting between Canada and the rest of the world.

They develop a numerical general equilibrium model in order to highlight the importance of tax exporting in determining the welfare effects of tax changes in open economies. In their model the authors emphasise the importance of including foreign tax credits when modelling the supply of foreign capital.[4] In this context, tax exporting occurs either through a change in the terms of trade or through a change in the net return paid to foreign-owned capital employed in Canada. Damus' et al measure of the aggregate welfare change (ΔW) resulting from a given tax change includes a tax exporting (TEE) effect and an efficiency effect (DWL), that is,

$$\Delta W = TEE + DWL , \qquad [1]$$

where ΔW is calculated as the sum of equivalent variations across income groups; TEE captures the possibility of exporting tax burdens to non-residents (foreigners); and DWL is the efficiency effect (dead-weight loss or gain) associated with a given tax change, which captures the impact on resource allocation resulting from any change in the overall pattern of taxation in the economy.

The results of Damus et al (1991) indicate that tax exporting effects may be as significant as efficiency effects in evaluating potential reforms. Furthermore, efficiency effects may be influenced by the way foreign capital flows are modelled.

More recently, Morgan et al (1996) analyse long-run exporting and importing of regional taxes using a six-region general equilibrium model of the United States. They conclude that the ability of states to export taxes does not necessarily promote economic growth or welfare. In addition, factor tax exporting depends on regional ownership patterns and the determinants of factor prices, such as factor mobility, factor intensities, and elasticities of substitution in production.

---

[4] In this chapter foreign tax credits are not considered.

As indicated above, the literature I have reviewed mainly focuses on the exportation of state and local taxes to other regions within the same country, with the exception of Damus et al (1991). In what follows, I investigate whether developed countries export factor taxes to developing countries, contributing to the deterioration of their terms of trade and welfare.

3.3 THE MODEL

The general equilibrium model used to analyse tax exporting is a standard multicountry model that incorporates domestic tax structures in each region. The model is static and consists of eight regions, each one with a demand and production structures.[5] The regions are linked through trade. Each region has three industries, each of which produces a single output. There are two factors of production (namely labour and capital) which are used as primary inputs; for simplicity, intermediate production is not considered. There is a representative consumer by region.

Commodities are considered to be qualitatively different from similar commodities produced abroad. This is the Armington assumption (Armington, 1969), widely used in international trade applied general equilibrium analysis, to account for the presence of cross hauling in international trade data. In addition, the use of the Armington assumption rules out complete specialisation, and allows us to establish the strength of the terms of trade effect by introducing estimates of trade elasticities (Whalley, 1985).

[5] In the empirical implementation (section 3.4) it is explained how these regions were chosen.

3.3.1 PRODUCTION SIDE OF THE MODEL

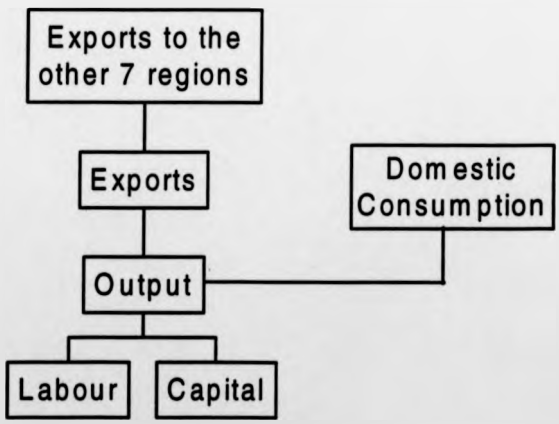
On the production side of the model, in each region there are three industries each using labour (L) and capital (K) as inputs. Production exhibits constant returns to scale and firms are perfectly competitive, so that prices equal marginal costs of output. The production structure in each industry is summarised in Figure 3.1, and the formal equations and notation used in the model are presented in Appendix 3.1.

A constant elasticity of substitution (CES) production function describes the substitutability between L and K into value added for each industry in each region. More formally, the value added function for industry i, in region r, is given by,

$$Q_i^r = \gamma_i^r [\delta_i^r L_i^{r\,(\sigma_i^r-1)/\sigma_i^r} + (1-\delta_i^r) K_i^{r\,(\sigma_i^r-1)/\sigma_i^r}]^{\sigma_i^r/(\sigma_i^r-1)} \quad \text{for i = 1,...,N; r=1,...,R,} \qquad [2]$$

where Q_i^r is the value added in industry i in region r; γ_i^r is a constant defining units of measurement; δ_i^r is a share parameter; σ_i^r is the elasticity of substitution between labour and capital in the production of good i.

Figure 3.1: Production structure in each sector



Each industry selects an optimal level of inputs that minimises the cost of producing Q units of output. Further, each industry in each region produces a commodity that can be transformed either into a commodity sold on the domestic market, or into an export according to a constant elasticity of transformation (CET) function. In a second stage, exports are allocated across regions according to a sub CET function.

Factors are non-produced commodities in fixed supply in each region. It is assumed that both factors are mobile across industries within the region. Regarding international factor mobility, labour is assumed to be internationally immobile because of restrictions to international labour mobility. As to capital, in global models international mobility is usually ignored (e.g. Whalley, 1985; Shoven and Whalley, 1992). However, in their analysis of domestic tax policies and the foreign sector, Goulder et al (1983) point out that the incorporation of international capital mobility can substantially affect the results of the model.[6] In addition, capital markets are becoming more integrated internationally. Hence, it seems appropriate to consider two variants of the model: one in which both labour and capital are assumed to be internationally immobile, and another one in which capital is internationally mobile.[7]

3.3.2 DEMAND SIDE OF THE MODEL

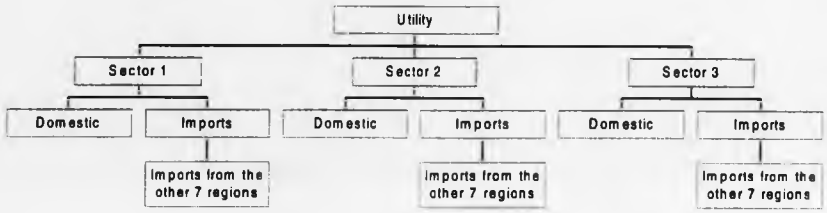
On the demand side of the model, it is assumed that consumers within a region have identical homothetic preferences. This assumption allows us to consider a

[6] See Gasiorek et al (1992) for a presentation of a multicountry computable general equilibrium model with perfect international capital mobility.

[7] Whalley (1985) mentions that the absence of international factor mobility follows the tradition of the Heckscher-Ohlin literature. This assumption can be crucial for model results, since factor mobility can be a substitute for trade. Moreover, "... factor flows in a Heckscher-Ohlin framework can equalise relative factor endowments across countries, removing the source of trade. Global gains from liberalised factor mobility, ... , can thus be just as important as global trade liberalisation" (Whalley 1985, p.36).

representative consumer, endowed with all the labour and capital in the region. The consumer maximises a nested CES utility function subject to the regional budget constraint.[8] The nesting structure used for each region in the CES final demand function is summarised in Figure 3.2, and the complete set of equations and notation that defines the demand side of the model is presented in Appendix 3.1.

Figure 3.2: Nested utility structure



At the top level, consumers decide how much to spend on goods from each sector given the regional budget constraint. Consumers demand a composite of similar imported and domestically produced goods. At the second level, the consumer determines domestic and aggregate import expenditure in each sector according to a CES function.[9] At the third level, purchases of imports from each region are selected in each sector, according to a CES function.[10]

The budget constraint in each region is given by income equal expenditure ($I^r = E^r$), where income is derived from factor ownership, government transfers and the

[8] It seems appropriate to use a nested CES utility function because it allows us to use a different elasticity of substitution for each level. In contrast, in a single-stage CES function only one elasticity of substitution can be specified, and this applies for all goods appearing in demands. In this case, if all expenditure shares are small, the value for the compensated own-price elasticity for all goods would be approximately the same (Whalley, 1985).

[9] The substitution between comparable domestic and composite imports determines the price elasticity of demand for imports.

[10] The substitution among imports from the other 7 regions determines export-price elasticities faced by the region.

region's current account deficit. On the other hand, the region's expenditure includes the amount spent on the goods as well as taxes paid.

3.3.3 TREATMENT OF POLICIES

In addition to demand and production structures, the model also incorporates some policy elements that may have regional effects, such as factor, income and consumption taxes, as well as import tariffs. Domestic taxes, especially factor taxes, affect the cost structure of domestic output. Since part of this output is exported, the degree of tax exporting will depend on how much the price of the exported output is increased by the domestic tax, and the fraction of output purchased by non-residents.[11]

Factor taxes are modelled as ad valorem taxes on the use of factors of production, and so will affect the price paid by producers. These taxes are exported mainly due to intersectoral effects.

Income taxes are modelled as an ad valorem tax on taxable income. This tax is paid by residents and cannot be exported. However, it seems appropriate to consider this tax in the formulation of the model, since in some countries there exists double taxation of corporate income, that is at the firm and shareholders levels.

Consumption taxes are modelled as ad valorem taxes on final consumption, and therefore affect the price paid by consumers. Consumption taxes cannot be exported since the possibility of commuting is not considered; that is, in the model workers purchase goods in the region where they live. These taxes are included

[11] This is what McLure (1969) refers to as tax exporting from the uses side.

because in the counterfactual experiments, domestic taxes are eliminated and replaced by an equal yield non-distorting tax on final expenditure.

Import tariffs are modelled as an ad valorem tax on imports, with rates varying across commodities. Import tariffs are not exported, but are used to alter the terms of trade of a country with respect to its trading partners. Finally, all tax revenues raised are assumed to be transferred back to consumers.

3.3.4 EQUILIBRIUM CONDITIONS IN THE MODEL

Once the model has been specified, it can be solved for an equilibrium solution. A general equilibrium in the model can be interpreted in the usual Walrasian sense as a set of prices for which all markets clear. That is demand-supply equalities hold in each goods and factors markets; zero profit conditions hold for each industry in each region; and each region is in external-sector balance. Appendix 3.1 formally presents the full set of equilibrium conditions of the model.

In the goods market, gross output equals final demand because intermediate production is netted out; specifically, the model has the following blocks of market clearing conditions:

- The supply of goods for domestic consumption must equal the demand for domestically produced goods.
- Exports from region r to region s must equal imports of region s from region r, because there are assumed to be no transfer (e.g. transport) costs in shipping goods from one region to another.
- Total supply of composite commodities, which consists of the composite of similar domestic products and aggregate imports, must equal consumer's demand in each region.

Regarding factor markets, it is initially assumed that both factors are intersectorally mobile within each region, but internationally immobile. The first assumption implies that there is only one price for each factor in each region. The second assumption implies that factor prices are different in each region, and this is a crucial assumption for the results of the model, since market clearing conditions in factor markets determine factor prices. Under these assumptions, there are separate labour and capital equilibrium conditions in each region. That is, factor use across all industries by region must equal the region's endowment of labour and capital (i.e. there is full employment in all regions).

In the second variant of the model capital is assumed to be internationally mobile. This assumption implies that there is only one price for capital in the model, and this is determined by the market clearing condition that factor use across all industries and regions must equal the world endowment of capital (i.e. relative to the model with international capital immobility, the capital market clearing conditions within countries are dropped).

In addition, zero profit conditions must hold for each industry in each region; in particular:

- In each region the value of domestic output in sector i must be equal to the capital and labour costs of producing good i. At the same time, the value of domestic output in sector i equals the value of commodities sold in the domestic market plus the value of commodities sold as exports.
- Export aggregation, that is the value of commodities sold as exports, must equal the value of the sum of exports to the other 7 regions.
- Import aggregation, that is the value of total imports, must equal the value of the sum of imports from the other 7 regions.

- The value of the composite commodity i demanded by consumers must equal the value of aggregate imports plus the value of domestically produced goods.
- The value of goods sold for domestic consumption must be equal to the value of the demand for domestically produced goods.
- The value of exports from region r to region s must be equal to the value of imports of region s from region r.

Finally, an external sector balance condition for each region is included. This equilibrium condition indicates that each region is always on its budget constraint. In the model, this condition states that the value of exports minus the value of imports, that is the trade surplus (or deficit), remains fixed in real terms.[12]

Having presented the equilibrium conditions that characterise the model, I proceed to introduce the benchmark data set to be used in the simulations. In addition, I calculate the parameters of the model that are consistent with the data set and that together with the elasticities (that are exogenously specified), reproduce the data set as an equilibrium solution of the model.

3.4 EMPIRICAL IMPLEMENTATION

The model consists of eight regions, each of which engages in both domestic and foreign trade activities. No internal trade among the countries of any region is included. These regions were chosen to reflect world trade. Instead of having two big regions called "developed countries" and "developing countries", it was decided to split each group into four sub-groups. The advantage of this additional classification is that it allows us to consider from which region(s) developing sub-groups are likely

[12] The trade balance is not equal to zero, since this involves adjusting the data.

to "import" taxes. Developed regions were chosen to represent the main trading areas in the developed world, that is the United States (USA), Japan (JAP), the European Union (12-member-EU), and the remaining developed countries were grouped in other development countries (ODC). Developing regions comprise a heterogeneous group of countries, and were chosen according to their geographical location, that is developing America (DAM), developing Africa (DAF), developing Asia (DAS), and developing Europe (DE).[13] Table 3.1 presents the grouping of individual countries.

The regional classification described above is important since domestic tax policy in developed regions may affect one developing region more than another. Also, developing regions have more commercial ties with one developed region than with others. For example, the USA is the main market for developing America due to its proximity, as it is the case between Japan and developing Asia. The European Union is the main market for African products, not only because of their proximity but also because there are still colonial ties and institutional agreements (e.g. EU-ACP). Lastly, developing Europe is increasingly trading with the European Union mainly as a result of the opening up of the countries in Eastern Europe, and the possibility of enlargement of the European Union.

The model uses 1990 data. This was the latest consistent year available at the time of building the benchmark data set.

[13] Initially, developing Oceania (which included Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, and Vanuatu) was included as a ninth region. At the time of solving the model I encountered numerical problems because this region was very small compared to the others (in 1990 its GDP accounted for only 0.2% of world GDP). Hence, it was excluded from the analysis.

Table 3.1: Regional classification

Region 1: USA	United States			
Region 2: JAP	Japan			
Region 3: EU	Belgium	Denmark	France	Germany
	Greece	Ireland	Italy	Luxembourg
	Netherlands	Portugal	Spain	United Kingdom
Region 4: ODC	Australia	Austria	Canada	Finland
	Iceland	Israel	New Zealand	Norway
	South Africa	Sweden	Switzerland	
Region 5: DAM	Antigua & Barbuda	Argentina	Barbados	Belize
	Bolivia	Brazil	Chile	Colombia
	Costa Rica	Dominica	Dominican Rep.	Ecuador
	El Salvador	Grenada	Guatemala	Guyana
	Haiti	Honduras	Jamaica	Mexico
	Nicaragua	Panama	Paraguay	Peru
	St. Lucia	St.Kits & Nevis	Suriname	Uruguay
	Trinidad & Tobago	Venezuela	St. Vincent & the Grenadines	
Region 6: DAF	Algeria	Angola	Benin	Botswana
	Burkina Faso	Burundi	Cameroon	Cape Verde
	Central African Rep.	Chad	Comoros	Congo
	Cote d'Ivoire	Djibouti	Egypt	Equatorial Guinea
	Ethiopia	Gabon	Gambia	Ghana
	Guinea	Guinea-Bissau	Kenya	Lesotho
	Madagascar	Malawi	Mali	Mauritania
	Mauritius	Morocco	Mozambique	Namibia
	Niger	Nigeria	Reunion	Rwanda
	Sao Tome & Principe	Senegal	Seychelles	Sierra Leone
	Sudan	Swaziland	Togo	Tunisia
	Uganda	Tanzania	Zambia	Zimbabwe
Region 7: DAS	Bahrain	Bhutan	Bangladesh	China
	Hong Kong	India	Indonesia	Iran (Islamic Rep)
	Jordan	Kuwait	Laos	Lebanon
	Malaysia	Mongolia	Myanmar	Nepal
	Oman	Pakistan	Philippines	Qatar
	Rep. of Korea	Saudi Arabia	Singapore	Sri Lanka
	Syrian Arab Rep.	Taiwan	Thailand	Yemen
	United Arab Emirates			
Region 8: DE	Bulgaria	Croatia	Cyprus	Czech Rep.
	Estonia	Hungary	Malta	Poland
	Romania	Slovenia	Turkey	USSR (former)
	Yugoslavia (former)			

3.4.1 COMMODITIES CONSIDERED

As mentioned previously, intersectoral effects play an important role in the exportation of domestic taxes. It would be desirable to include a wide range of commodities in the model. However, given that the analysis involves a large number of countries, it is difficult to find the same data for every country. For example, in some countries production data are disaggregated, but this is not the case for foreign trade data (or vice versa). Also, in some countries the cost components of value added are not available. Hence, it was necessary to find a commodity classification such that production and foreign trade data were available for as many countries as possible.

In the model, each region is assumed to produce three commodities: primary commodities (including fuels), manufactured goods, and services. It is also assumed that each region's domestically produced and imported goods are qualitatively different (i.e. the Armington assumption). Appendix 3.2 presents the sources and how the data set was assembled.

3.4.2 TREATMENT OF POLICIES

In the model, both commercial and domestic tax policies are considered. Commercial policy is represented by import tariffs, applied in ad valorem form; tariff collections are part of the government's revenues.[14] As to domestic taxation, factor, income and consumption taxes are incorporated in the domestic transactions of each region. Factor taxes include corporate and property taxes, treated as taxes on the use of capital by industry, and payroll taxes and social security contributions, treated as

[14] Import tariffs were included because of their effect on both regional terms of trade and welfare.

taxes on the use of labour by industry.[15] Income taxes are treated as taxes on consumer's taxable income. Consumption taxes include value added tax, sales tax and some specific taxes on consumption. All taxes are in ad valorem form. Lastly, foreign tax credits are not included in the model.

Tax rates are calculated by dividing tax revenues (as taken from the benchmark data set) by the model tax base, obtaining an average effective tax rate. For simplicity, in applied general equilibrium models it is assumed that marginal tax rates equal the observed average tax rates. However, Fullerton and Gordon (1983) indicate that for some taxes[16], there is no reason to assume that average and marginal tax rates are equal, and that marginal tax rates should be used instead. King and Fullerton (1984) point out that "...the difference between average tax rates and marginal tax rates primarily involve distinctions between ex post taxes paid and ex ante expectations of taxes using current legislation" (p. 266). The use of marginal tax rates, however, is also subject to criticisms as indicated by Shoven and Whalley (1984). They emphasise that various alternative tax rates can be calculated depending on "...more characteristics than can adequately be captured by the models..." and hence, this is "...inappropriate because distortions at the appropriate margins are not fully represented" (p. 1031).

Table 3.2 shows the tax rates used in the model. As can be seen, the resulting tax rates are quite low; in addition, income tax rates, factor taxes and taxes on domestic goods and services are higher in developed regions than in developing

---

[15] From the available data it was only possible to calculate one tax rate by factor tax in each region. Since intersectoral effects play an important role in the model, the data set was also modified to include differential tax rates by industry in order to assess the sensibility of the results (Appendix 3.2 presents the procedure followed to calculate the differential tax rates).

[16] These authors re-examine the modelling of the property tax, unemployment insurance, workmen's compensation, and social security, and present the effects of corporate and personal taxes on firms' financial and investment decisions.

regions. The collection of tax revenue in developing countries is often limited by their administrative capacity and political constraints. One consequence of this is that direct taxation plays a much more limited role in developing than in developed regions. Hence, developing regions exhibit a heavier reliance on indirect taxation, especially taxes on international trade.

Table 3.2: Model-equivalent ad valorem tax rates used in the model (%)

	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
1. Taxes on the use of capital								
Corporate tax	5.3	11.3	6.3	6.3	5.0	6.0	7.6	3.3
Property tax	0.7	1.7	2.1	1.6	1.5	0.4	1.0	0.1
2. Taxes on the use of labour								
Payroll tax	0.0	0.0	0.2	0.9	0.5	0.5	0.3	2.1
Social security contributions	11.3	16.7	24.9	10.5	8.5	8.0	1.5	3.6
3. Taxes on domestic goods and services [1/]								
Primary commodities	3.0	1.1	5.2	3.4	5.3	0.5	0.4	3.9
Manufactured goods	4.4	14.3	11.2	3.6	7.2	6.5	11.8	4.2
Services	8.1	5.0	10.4	11.8	4.1	0.1	7.5	0.7
4. Income tax	9.2	6.2	8.3	9.2	0.2	1.6	1.4	3.0
5. Import tariffs								
Primary commodities	13.5	9.3	15.0	9.3	20.2	53.6	33.2	15.7
Manufactured goods	5.2	4.9	5.4	7.7	21.6	30.2	30.0	11.3
Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[1/] Includes mainly commodity excise taxes, and retail sales taxes.
Source: Author's own calculations, as described in Appendix 3.2.

During the nineties there have been some changes in tax policy (International Bureau of Fiscal Documentation, various years). The general trend has been towards reduced rates of personal income tax and corporate tax. There has also been a shift towards indirect taxation as a mean of collecting revenue. Some countries with fiscal difficulties (e.g., Japan, Thailand, Pakistan, the Middle East countries) have chosen to rely on indirect taxation either by increasing the tax rate or by broadening the tax base. Other countries (e.g., Mongolia, Nepal, Sri Lanka, Zambia, Ghana) have

introduced VAT, and in some other cases (e.g., Japan, Pakistan, Thailand, Ivory Coast, Niger) VAT systems have been simplified by reducing the number or rates. The general trend among Latin American countries has been the increase of VAT. In Central Europe changes have also been made in with a view to harmonising corporate taxation and VAT with the European Union.

Reductions in corporate income taxes have been observed in countries such as Korea, the Solomon Islands, Bangladesh, Ireland, Kenya, Lesotho, Zimbabwe. Other countries (e.g., Japan, Korea, Malaysia, Bangladesh, Singapore, Pakistan, the Solomon Islands, Sri Lanka, South Africa, Zimbabwe, Botswana) have been reducing the burden of individuals by rate reductions, a widening of tax bands or one-off rebates, or by a combination of these.

Regarding direct taxation, the general trend has been to protect the tax base, often accompanied by reduced or at least stable tax rates. Also, anti-avoidance / anti-evasion measures have been strengthened in order to deal with international tax avoidance and new business practices. Perhaps as a result of the increased competition brought about by globalisation, one of the main features world-wide has been the enactment of measures design to attract investment (exemptions and other tax concessions), sometimes limited to specific sectors (e.g. the oil sector in Nigeria). The Netherlands have introduced tax incentives in order to make the investment climate more attractive: these include the extension of incentives to research and development activities, by allowing accelerated or free depreciation for certain new assets, and relaxing significantly its ruling policy.

Virtually all countries in the world continued to expand their tax treaty networks, particularly in Africa and the Middle East, and several countries have been reducing their import tariffs in the continuing move towards freer markets.

3.4.3 BENCHMARK DATA SET, CALIBRATION AND ELASTICITIES

The benchmark data set involves data on value added by component by industry, domestic taxes, foreign trade and import tariffs. Given that the model considers a representative consumer in each region, the final demand for domestic products is equal to gross output minus exports, whereas the final demand for imported products equals imports.

The size of the eight regions is given by their respective GDP, in 1990 US dollars, as reported in the World Tables (World Bank, 1995). The benchmark data set satisfies the equilibrium conditions of the model in the presence of the existing policies. I use data from National Accounts as compiled by the United Nations, World Tables produced by the World Bank, and the Government Finance Statistics Yearbook of the International Monetary Fund. Regarding foreign trade statistics, I use information from UNCTAD (1995) and the GATT-trade policy review. A detailed presentation of the sources and how the data set was assembled is presented in Appendix 3.2.

Once the data set has been assembled, some parameter values, such as share parameters and scale parameters, can be directly calculated from the equilibrium conditions of the model, following the procedure described in Mansur and Whalley (1984). Because of the CES/CET functional forms used in the model, some parameter values for the elasticities of substitution and the elasticities of transformation need to be specified. Then, on the demand side, share parameters can be obtained from demand functions. On the supply side, share and scale parameters can be obtained from cost functions.

The results of the model are dependent on the values selected for the elasticities of substitution. Trade elasticities determine the strength of the terms of trade effects associated with trade policies. These terms of trade effects, together with production and consumption effects, which also depend on the elasticities chosen, determine the welfare effects of any policy change. Sensitivity analysis is performed around the values chosen.

On the demand side, the model involves elasticities of substitution in consumption between composite goods; elasticities of substitution between comparable imported and domestically produced goods; and elasticities of substitution between imported products. In this case, the elasticities used are based on price elasticity estimates, since it was not possible to find econometric estimates of elasticities of substitution for CES demand functions. The elasticity of substitution between composite commodities was set equal to one in all regions; these elasticities imply Cobb-Douglas demand functions.

The elasticity of substitution between comparable imported and domestically produced goods (υ) was set equal to literature estimates of import price elasticities (see Table 3.3). Within each region the same value was assumed for all commodity-substitution possibilities (Appendix 3.3 presents a description of the sources). Lastly, since substitution between import types forming import composites determines the export price elasticity faced by the region, the elasticity of substitution between imports forming import composites (ζ) was set equal to estimates of export price elasticities obtained from the literature (see Table 3.3 and Appendix 3.3).

Table 3.3: Elasticities in the model

Elasticity	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
σ								
Primary Commodities	0.70	0.62	0.64	0.70	0.77	0.70	0.70	0.70
Manufactured goods	0.78	0.79	0.81	0.81	0.90	0.81	0.81	0.81
Services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ρ								
Primary Commodities	-0.77	-0.77	-0.77	-0.77	-0.77	-0.77	-0.77	-0.77
Manufactured goods	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75
Services	-0.95	-0.95	-0.95	-0.95	-0.95	-0.95	-0.95	-0.95
ε								
Primary Commodities	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17
Manufactured goods	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17
Services	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17	-1.17
υ								
Primary Commodities	0.92	0.93	0.86	0.95	1.26	1.02	1.55	2.72
Manufactured goods	0.92	0.93	0.86	0.95	1.26	1.02	1.55	2.72
Services	0.92	0.93	0.86	0.95	1.26	1.02	1.55	2.72
ζ								
Primary Commodities	0.99	0.93	0.92	1.13	0.54	0.57	1.23	1.41
Manufactured goods	0.99	0.93	0.92	1.13	0.54	0.57	1.23	1.41
Services	0.99	0.93	0.92	1.13	0.54	0.57	1.23	1.41

Notes:
σ is the elasticity of substitution between capital and labour; based on estimates presented in Whalley (1985).
ρ is the elasticity of transformation for domestic output; taken from de Janvry et. al. (1991).
ε is the elasticity of transformation for exports. These elasticities appear to be identical when the figures are rounded to two decimal places.
υ is the elasticity of substitution between domestic and imported goods. This elasticity was set equal to literature-survey import price elasticities. Within any region, the same value is used for all commodity-substitution possibilities.
ζ is the elasticity of substitution between regional imports. This elasticity was set equal to literature-survey export price elasticities. Within any region, the same value is used for all commodity-substitution possibilities.
Source: See Appendix 3.3.

Shiells and Reinert (1993) point out that estimated Armington elasticities are low; thus, there are large terms of trade effects losses associated with trade liberalisation. They also state that the value chosen for the elasticity of substitution among imports from different sources clearly affects trade, terms of trade and the welfare effects of bilateral tariff reductions.

The Armington assumption has been criticised by Brown (1987), in the sense that it may imply large terms of trade effects regardless of the size of the country. Brown also shows that the terms of trade effect would increase in magnitude, the larger the elasticity of substitution between comparable imported and domestically produced goods, and the smaller the elasticity of substitution between import types.

Regarding the supply side, the elasticity of substitution between labour and capital (σ) is the key parameter of the value added functions. I use elasticities of factor substitution by industry based on those used by Whalley (1985). With regard to the elasticities of transformation for domestic output (ρ), it was not possible to find econometric estimates, so that the elasticities of transformation estimated for Ecuador by de Janvry et al (1991) were used. The strong assumption adopted here is that the same elasticity values apply by industry for all the regions in the model. Finally, it was not possible to find econometric estimates of the elasticity of transformation for exports (ε); hence, these parameters were calculated such that the elasticity of supply was equal to one. Once all parameters have been specified, the model can be solved for counterfactual experiments. The model was solved using a routine I wrote in GAMS.

3.5 Model results

In this section a set of simulations is performed to investigate whether developed countries export taxes to developing countries. Seven counterfactual experiments are carried out in which existing taxes and import tariffs are eliminated and replaced by an equal yield non-distorting tax. These experiments involve the elimination an replacement of: i) capital taxes; ii) labour taxes; iii) all factor taxes; iv) import tariffs; v) all factor taxes and import tariffs vi) income taxes; and vii) all factor taxes, import

tariffs, and income taxes. The equal yield non-distorting tax is a destination-based tax on final expenditure within the region.[17] Whalley (1980a) points out that the introduction of an equal yield non-distorting tax may not be very realistic. However, it allows us to appraise the effect domestic taxes may have on both welfare and terms of trade of the region's trading partners.

The counterfactual experiments were performed individually for USA, JAP, and EU, and for all developed regions simultaneously.[18] Further, the cases of international factor immobility and international capital mobility were considered.

After each change was introduced, a new equilibrium was calculated and the results were compared with the benchmark equilibrium. I am mainly interested in the impact of each policy change on the regional terms of trade and on welfare. The terms of trade were calculated for each region in its trade with all other regions, and correspond to a quantity weighted price index giving the relative price of exports and imports. The quantity weights used correspond to those associated with the benchmark equilibrium. A reduction in the price of a region's exports relative to that of its imports implies a deterioration in the terms of trade of the region, whereas an increase in this relative price implies a terms of trade improvement.

The welfare effects of the policy changes are measured by the Hicksian Equivalent Variation (EV) for each region, where a positive EV refers to a welfare improving change and vice versa. A positive EV could be the result of the removal of domestic distortions that affect producer and/or consumer decisions. Distortions to

[17] The possibility of using an origin-based tax was not considered because the introduction of this kind of tax may increase the price of domestic output, and in consequence the price of exports.

[18] Counterfactual experiments were also performed for the region comprising other developed countries (ODC). These results are not reported since I am interested in tax exporting from developed to developing regions, and the replacement of taxes in the ODC region mainly affects USA, JAP and EU.

producer decisions are caused by the effects of taxes on producer prices, whereas distortions to consumer decisions are caused by the effect differential factor taxation can have on output prices.

In the scenario with international capital mobility, the welfare effects will be decomposed according to equation [1] into a tax exporting effect (TEE) and an efficiency effect (DWL) (Damus et al, 1991). TEE is measured as:

$$TEE = V_E \hat{P}_E - V_M \hat{P}_M ,$$

where V_E and V_M correspond to the initial values of exports and imports, respectively; and $\hat{P}_E$ and $\hat{P}_M$ denote tax-induced percentage changes in the producer prices of exports and imports, respectively. Then, from [1] it follows that efficiency gains (losses) are given by the difference between the aggregate welfare change and the tax exporting effect, that is:

$$DWL = \Delta W - TEE.$$

DWL captures the impact a change on the overall pattern of taxation in the economy has on resource allocation.

If a region is exporting domestic taxes to another region, one would expect that an increase in such taxes will cause a deterioration in the terms of trade of the importing region as well as a welfare loss. For the exporting region an improvement in the terms of trade is expected, but the welfare effects could go either way. That is, the exporting region could experience a welfare gain or loss, because with the increase in the tax an additional distortion is introduced. The final result will depend on whether the terms of trade effect or the efficiency effect dominates.

A priori one might expect that the USA is mainly exporting taxes to DAM, since the former is the main trading partner of the latter; similarly, JAP is expected to

export taxes to DAS, while EU is expected to export taxes to DAF and to a lesser extent to DE.

3.5.1 MODEL RESULTS: FACTOR IMMOBILITY

Tables 3.4 and 3.5 present the results of the experiments when factors of production are assumed to be internationally immobile. Focussing first on the replacement of factor taxes (labour, capital, and both), a common feature of the results is that there are small welfare changes and small terms of trade effects since the burden of the taxes is borne by the factors themselves (see Table 3.4). Further, the replacement of taxes on labour produces stronger terms of trade effects, which can be explained by the fact that labour taxes are higher that those on the use of capital.

Table 3.4: Welfare and terms of trade effects of an equal-yield tax replacement of existing factor taxes
Factor immobility

Replacement of taxes in:	Taxes on labour		Taxes on capital		All factor taxes	
	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change
1. *USA*						
USA	812	0.12	228	0.03	1,040	0.16
JAP	-102	-0.04	-29	-0.01	-131	-0.05
EU	-186	-0.03	-52	-0.01	-238	-0.03
ODC	-180	-0.03	-50	-0.01	-230	-0.04
DAM	-882	-0.06	-25	-0.02	-113	-0.07
DAF	-19	-0.02	-5	-0.01	-25	-0.02
DAS	-115	-0.03	-32	-0.01	-148	-0.04
DE	-10	-0.01	-3	-0.00	-13	-0.01
Total	-683		32		143	
2. *JAP*						
USA	248	0.04	135	0.02	384	0.06
JAP	-307	-0.17	-164	-0.09	-486	-0.26
EU	185	0.02	101	0.01	286	0.04
ODC	20	0.00	11	0.00	31	0.01
DAM	8	0.00	4	0.00	12	0.01
DAF	7	0.01	4	0.00	11	0.01
DAS	91	0.01	49	0.01	141	0.02
DE	5	0.00	3	0.00	8	0.01
Total	256		142		387	
3. *EU*						
USA	-20	-0.00	-5	-0.00	-24	-0.00
JAP	14	0.00	3	0.00	170	0.01
EU	513	0.06	127	0.02	637	0.08
ODC	-125	-0.02	-31	-0.01	-156	-0.03
DAM	-43	-0.03	-11	-0.01	-54	-0.03
DAF	-126	-0.12	-31	-0.03	-157	-0.15
DAS	-83	-0.02	-21	-0.01	-104	-0.03
DE	-40	-0.03	-10	-0.01	-50	-0.04
Total	90		23		263	
4. *USA, JAP, EU, ODC*						
USA	679	0.10	228	0.03	907	0.13
JAP	-482	-0.24	-220	-0.11	-716	-0.35
EU	13	-0.01	-37	-0.00	0	-0.01
ODC	1,032	0.16	404	0.06	1,433	0.23
DAM	-139	-0.09	-37	-0.02	-175	-0.11
DAF	-164	-0.15	-42	-0.04	-205	-0.19
DAS	-211	-0.06	-41	-0.01	-250	-0.08
DE	-81	-0.07	-23	-0.02	-103	-0.09
Total	647		233		890	

Note: Totals may not add up due to rounding.

When USA and EU unilaterally replace factor taxes, factors of production move out of manufactures into primary commodities and services. As a result, a reduction in exports (especially of manufactures) is observed as well as an increase in output for domestic consumption. Since USA and EU reduce their exports, there is a small reduction in aggregate consumption in all other regions, and they suffer a welfare loss. USA and EU obtain welfare gains; this means that factor taxes in USA and EU were a source of loss for the regions, so that when they are replaced there is a gain in domestic efficiency. There are also small improvements in terms of trade of USA and EU, and a very small deterioration in the other regions.

In the case of JAP, the replacement of factor taxes generates a welfare loss for the region and a small deterioration of its terms of trade. In this case factors of production are reallocated towards manufactured goods, which increases exports and reduces output for domestic consumption. At the same time, there is an increase in imports that is not enough to compensate the reduction in output for domestic consumption. Hence, there is a small welfare loss of around 0.005% of GDP. This result suggests that factor taxes did not constitute a source of loss for JAP. The welfare loss occurs despite the productive efficiency gain, and is caused by the deterioration of the terms of trade (0.3%). Since JAP is increasing its exports, there is a small increase in all other regions aggregate consumption and small welfare gains. There are also small improvements in the terms of trade of these regions.

When all developed regions (i.e., USA, JAP, EU, and ODC) replace factor taxes, factors of production reallocate towards services in USA and ODC, services and manufactured goods in EU, and manufactured goods in JAP. As a result a reduction in total exports is observed in USA, EU and ODC, and an increase in output for domestic consumption. There is also an increase in JAP's exports, and in

consequence a reduction in output for domestic consumption. This increase in JAP's exports is not enough to compensate the reduction in exports from USA, EU and ODC, leading to a reduction in aggregate consumption and a welfare loss for developing regions; also, terms of trade deteriorate in these regions. Factor taxes were a source of loss for USA, EU and ODC; these regions obtain welfare gains as a result of the terms of trade effect. For JAP, they did not constitute a source of loss although there is a welfare loss despite the efficiency gain, caused by the deterioration of its terms of trade (0.5%). Qualitatively similar results are obtained when all eight regions simultaneously replace factor taxes: that is, developing regions suffer welfare losses and terms of trade worsening, whereas developed regions (except JAP) are better off (the results are not reported here).

In summary, when production factors are assumed to be internationally immobile, there is no tax exporting of domestic factor taxes to developing countries since the burden of the taxes is borne by the factors. In the case of JAP, the expected results for the existence of tax exporting are obtained, although the effects on both welfare and terms of trade are rather small. At this point it is important to point out that with a fixed amount of labour and capital, and with the assumption of factor immobility, factor taxes are borne by the factors themselves, so that the replacement of factor taxes by a non-distorting consumption tax would have no effect of equilibrium prices or quantities. However, in these experiments welfare gains (losses) and terms of trade improvement (deterioration) are obtained, and these can be explained by the fact that in the model the trade balance (deficit or surplus) in each region remains fixed in real terms. If instead one carries out the same experiments for the case in which there is a zero trade balance in each region (which

involves adjusting the data set), then, as expected, no effects on either welfare or terms of trade are observed.

Table 3.5 presents the effects of the replacement of import tariffs. When a region imposes an import tariff its welfare and terms of trade should improve, provided the region has market power. The results indicate that when import tariffs are unilaterally replaced in USA, JAP and EU, there are welfare losses of $16 billion (0.3% of GDP), $5 billion (0.2% of GDP), and $23 billion (0.4% of GDP), respectively. In these regions imports increase because they are now cheaper; at the same time there is an increase in exports of primary commodities and manufactured goods, since factors of production reallocate towards these sectors, hence reducing output for domestic consumption. The increase in imports is not enough to compensate for the reduction in domestic supply, so that there is a reduction in consumption. These welfare losses are accompanied by terms of trade deterioration of 2.5% for USA, 2.6% for JAP, and 3% for EU.

There are also welfare and terms of trade improvements in developing regions. The replacement of import tariffs by USA mainly affects the terms of trade of DAM (1.3%), the replacement of import tariffs in JAP improves the terms of trade of DAS by 0.8%, and the replacement of tariffs in EU improves the terms of trade of DAF and DE improve by 2.9% and 1.2%, respectively. The welfare gains in developing regions are obtained as a result of the terms of trade improvement.

When all developed regions simultaneously replace import tariffs, their terms of trade worsen and there are welfare losses. The welfare losses exhibited by developed regions are smaller than when the unilateral replacement of import tariffs took place. As expected, developing regions are better off and their terms of trade improve.

Table 3.5: Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs and factor taxes
Factor immobility

Replacement of taxes in:	Import tariffs		Import tariffs and factor taxes	
	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change
1. *USA*				
USA	-16,986	-2.54	-15,886	-2.39
JAP	1,764	0.67	1,634	0.62
EU	3,597	0.48	3,358	0.45
ODC	4,034	0.72	3,800	0.68
DAM	2,160	1.34	2,045	1.27
DAF	780	0.72	755	0.69
DAS	2,398	0.58	2,248	0.54
DE	234	0.19	220	0.18
Total	-2,018		-1,827	
2. *JAP*				
USA	2,012	0.34	2,392	0.41
JAP	-4,974	-2.61	-5,478	-2.86
EU	1,457	0.19	1,741	0.23
ODC	905	0.16	932	0.17
DAM	324	0.20	335	0.21
DAF	120	0.11	131	0.12
DAS	3,469	0.83	3,599	0.85
DE	95	0.08	102	0.08
Total	3,408		3,754	
3. *EU*				
USA	3,433	0.57	3,411	0.56
JAP	1,060	0.39	1,076	0.40
EU	-22,580	-3.00	-21,853	-2.92
ODC	7,731	1.38	7,557	1.35
DAM	1,317	0.81	1,259	0.77
DAF	3,134	2.89	2,968	2.73
DAS	4,255	1.01	4,141	0.98
DE	1,429	1.16	1,375	1.12
Total	-220		-66	
4. *USA, JAP, EU, ODC*				
USA	-5,910	-0.82	-4,935	-0.69
JAP	-634	-1.07	-1,384	-1.41
EU	-9,546	-1.41	-9,499	-1.41
ODC	-7,202	-0.84	-5,718	-0.63
DAM	4,145	2.58	3,958	2.47
DAF	4,445	4.12	4,230	3.92
DAS	11,732	2.83	11,454	2.75
DE	2,325	1.90	2,215	1.81
Total	-646		321	

Note: Totals may not add up due to rounding.

The last two columns of Table 3.5 look at the combined replacement of factor taxes and import tariffs. The results are qualitatively the same as when only tariffs are replaced; that is, there are welfare losses and terms of trade deterioration for the regions replacing the taxes. The other regions obtain welfare gains and their terms of trade improve. The magnitude of the effects are dominated by the effects of the replacement of import tariffs alone. During recent years, several countries have continued reducing their tariffs in the continuing move towards freer markets. Hence, the effects of the elimination of import tariffs on both welfare and terms of trade should have also reduced.

Then, the replacement of income taxes was considered. This tax is paid by residents, and so it cannot be exported. However, it seems interesting to perform this experiment since, as indicated before, in some countries there is double taxation of corporate income (at the firm and shareholders levels). Results not reported here indicate that the unilateral replacement of income taxes in USA and EU generates welfare gains (of 0.02% and 0.01% of GDP, respectively), and small terms of trade improvements (0.15% and 0.04%, respectively). When income taxes are eliminated in USA and EU, consumers increase their demand for final consumption goods. This demand is met by shifting domestic output from exports to the domestic market, so that there is an increase in aggregate consumption. The other regions are worse off and there is a small deterioration in their terms of trade.

When income taxes are replaced in JAP the results are similar to when factor taxes were replaced. That is, JAP suffers a welfare loss of 0.01% of GDP ($189 million) and a deterioration of 0.1% in its terms of trade. In this case, domestic factors are reallocated towards manufactured goods increasing total exports and reducing output destined for domestic consumption. At the same time, imports

increase but this is not enough to compensate the reduction in domestic supply. Hence, there is a reduction in aggregate consumption and a welfare loss. Welfare gains in other regions are small, as is the improvement in terms of trade.

Finally, the simultaneous replacement of factor taxes, income taxes and import tariffs was considered. Results not reported here indicate that when developed regions unilaterally replace existing taxes, they obtain welfare losses and their terms of trade worsen. The opposite effect occurs in developing regions. These results are dominated by the effects of the replacement of import tariffs.

In short, when factors of production are internationally immobile, import tariffs are more important than domestic taxes in their effects on both welfare and terms of trade. The results suggest that there is no tax exporting of domestic taxes by USA and EU to developing regions. In the case of JAP, the results indicate that there is tax exporting, but the effects on welfare and terms of trade are rather small.

3.5.2 Model results: International capital mobility

Tables 3.6 and 3.7 present the results for the experiments when capital is assumed to be internationally mobile. Focussing first on the replacement of labour taxes, the results are very similar to those obtained under the assumption of factor immobility; that is, the terms of trade effects are small, as well as the welfare gains or losses.

This case differs from the previous scenario in that the supply of capital in each region is no longer fixed; capital will move in response to changes in its rate of return. When labour taxes are replaced (see Table 3.6), the price of labour falls so that producers in USA, JAP, and EU demand more of it. However, labour is in fixed supply in each region, so that the price of labour goes up again in order to eliminate the excess demand. When labour taxes are unilaterally replaced in USA and EU the

welfare gains in these regions account for $0.7 and $0.4 billions, respectively, that is approximately 0.01% of GDP; the terms of trade improve by 0.1% in USA and 0.04% in EU. These gains are comprised of $2.5 and $0.3 billion tax exporting effects (gains for the regions) and $1.8 and $0.2 billion efficiency losses. These two regions attract capital from the other regions, leading to an increase in total output; exports in both regions reduce, being the increased output destined for domestic consumption. In the other regions there is less capital available, and this leads to a reduction in domestic production and exports. As a result, USA and EU imports reduce; the reduction in imports is more than compensated by the increase in output for domestic consumption, leading to an increase in aggregate consumption.

When labour taxes are unilaterally replaced in JAP, the region obtains losses of $0.3 billion (0.01% of GDP), whereas its terms of trade deteriorate 1.9%. This is comprised of a reduction in tax exporting of $0.5 billion, and an efficiency gain of $0.2 billion. In this case capital leaves the region, and hence there is a reduction in production. However, exports increase since factors of production reallocate towards manufactured goods. In the other regions, both production and exports increase because there is more capital available. Also these regions are better off as a result of the improvement in their terms of trade.

In the scenario in which capital taxes are replaced there are stronger terms of trade and welfare effects (see Table 3.6). In this case, capital moves out of the regions where capital taxes are in place, in order to avoid the tax and into the region(s) eliminating the tax(es). This is accompanied by a reduction in the marginal product of capital in the receiving region relative to that of labour, since labour is in fixed supply.

Table 3.6: Welfare and terms of trade effects of an equal-yield tax replacement of existing factor taxes
International Capital Mobility
($ millions)

Replacement	Taxes on labour				Taxes on capital				All factor taxes			
of taxes in:	EV	TEE	DWL	TOT	EV	TEE	DWL	TOT	EV	TEE	DWL	TOT
1. *USA*												
USA	721	2,547	-1,827	0.10%	-5,071	-5,327	256	-0.87%	-4,375	-2,227	-2,147	-0.77%
JAP	-121	-8,081	7,960	-0.04%	-788	3,160	-3,948	0.12%	-906	-5,244	4,338	0.09%
EU	-203	-3,184	2,981	-0.03%	-525	1,273	-1,798	0.01%	-723	-2,043	1,320	-0.01%
ODC	-131	4,624	-4,755	-0.02%	1,785	412	1,373	0.37%	1,656	4,991	-3,335	0.35%
DAM	-72	1,150	-1,222	-0.04%	803	483	320	0.57%	733	1,583	-850	0.53%
DAF	-19	-906	887	-0.01%	-92	349	-441	-0.01%	-110	-593	483	-0.03%
DAS	-101	9,999	-10,100	-0.02%	1,059	-2,567	3,626	0.29%	960	7,690	-6,731	0.26%
DE	-12	-6,149	6,137	-0.01%	-147	2,489	-2,635	-0.05%	-159	-3,914	3,756	-0.06%
Total	62	0	61		-2,976	271	-3,247		-2,925	242	-3,167	
2. *JAP*												
USA	225	211	14	0.04%	2,519	2,978	-459	0.48%	2,733	3,177	-444	0.51%
JAP	-314	-540	225	-0.17%	339	-8,857	9,196	-1.90%	-28	-9,346	9,318	-2.06%
EU	176	147	29	0.02%	1,006	1,343	-337	0.17%	1,172	1,481	-309	0.19%
ODC	41	49	-8	0.01%	712	829	-117	0.16%	752	877	-125	0.16%
DAM	12	14	-2	0.01%	221	231	-10	0.15%	232	244	-11	0.16%
DAF	6	5	1	0.01%	152	208	-56	0.16%	158	213	-54	0.16%
DAS	119	119	-0	0.02%	3,776	3,841	-65	0.75%	3,898	3,955	-58	0.77%
DE	2	-4	7	0.00%	-175	158	-333	-0.07%	-173	154	-327	-0.06%
Total	267	1	266		8,549	731	7,819		8,745	754	7,991	
3. *EU*												
USA	-30	-25	-4	0.00%	-554	-77	-476	-0.05%	-584	-103	-480	-0.06%
JAP	13	5	8	0.00%	-1,238	-377	-861	-0.10%	-1,227	-373	-854	-0.10%
EU	433	283	151	0.04%	-6,577	-8,741	2,164	-1.17%	-6,190	-8,461	2,271	-1.13%
ODC	-51	-41	-9	-0.01%	5,997	6,687	-690	1.17%	5,946	6,646	-700	1.16%
DAM	-34	-27	-7	-0.02%	177	300	-123	0.16%	144	273	-129	0.14%
DAF	-80	-66	-15	-0.06%	906	1,031	-125	1.09%	828	966	-138	1.03%
DAS	-58	-67	9	-0.02%	2,813	2,981	-169	0.65%	2,757	2,917	-160	0.63%
DE	-64	-62	-2	-0.04%	-1,386	-1,300	-86	-0.55%	-1,448	-1,360	-87	-0.59%
Total	130	1	130		138	504	-367		228	506	-278	
4. *USA, JAP, EU, ODC*												
USA	583	2,647	-2,064	0.13%	1,112	966	146	0.13%	1,750	3,371	-1,621	0.22%
JAP	-463	-8,395	7,931	-0.21%	-218	-5,178	4,960	-1.44%	-733	-13,221	12,487	-1.65%
EU	1,011	-2,265	3,276	0.11%	-1,121	-1,956	835	-0.33%	-1,155	-4,861	3,705	-0.34%
ODC	987	5,309	-4,322	0.15%	-1,887	-1,445	-441	-0.37%	-1,044	4,010	-5,054	-0.24%
DAM	-71	1,134	-1,205	-0.04%	1,201	989	212	0.90%	1,086	2,002	-916	0.83%
DAF	4,563	-2,280	6,843	-1.50%	6,015	5,578	437	0.10%	5,909	-585	6,494	0.01%
DAS	35	9,871	-9,836	0.00%	9,435	3,531	5,904	2.16%	9,334	15,271	-5,937	2.13%
DE	-24	-6,014	5,990	-0.02%	-1,843	-3,145	1,302	-0.60%	-1,950	-5,066	3,116	-0.68%
Total	6,621	8	6,613		12,694	-661	13,354		13,196	922	12,274	

EV: Equivalent Variation; TEE: Tax Exporting Effect; DWL: Deadweight gain (or loss); TOT: Terms of Trade.
Note: Totals may not add up due to rounding.

When capital taxes are unilaterally replaced by USA and EU, the welfare losses in these regions account for $5.1 and $6.6 billions, respectively, that is approximately 0.1% of GDP; the terms of trade worsen by 0.9% in USA and 1.2% in EU. These losses are comprised of $5.3 and $8.7 billion tax exporting effects (losses for the regions) and $0.3 and $2.2 billion efficiency gains. When capital taxes are replaced, the price of capital falls so that producers in USA and EU demand more of it. Hence, production increases as well as exports. In the other regions there is less capital available, and this leads to a reduction in domestic production and exports. As a result of this, USA and EU imports reduce, so that there is a reduction in aggregate consumption. As to the other regions, DAM benefits more when USA replaces its capital taxes than when EU does it; on the contrary, DAF benefits more when EU replaces its capital taxes (in fact, when USA replaces its taxes DAF loses $92 millions).

The terms of trade of USA and EU deteriorate since the price of their exports is lower after the replacement of capital taxes, and the price of their imports has gone up (due to the reduction in production for exports in the other regions). Also, the improvement of DAM's terms of trade is greater when USA replaces its taxes rather than EU (0.6% compared to 0.2%). The improvement of DAF's terms of trade is more significant when EU replaces its taxes (i.e. 1.1% compared to –0.01%).

When JAP replaces capital taxes it obtains a welfare gain of 0.01% of GDP, despite the fact that the terms of trade of this region deteriorate by 1.9% (because its imports are now more expensive). These gains are comprised of a reduction in tax exporting of $8.9 billion (loss for the region) and $9.2 billion efficiency gain. JAP also attracts capital, hence there is an increase in production and an increase in exports. In the other regions, both production and exports reduce because there is less

capital available. Also these regions (except DE) are better off as a result of the improvement in their terms of trade (especially DAS whose terms of trade improve 0.8%).

When USA, JAP, EU and ODC simultaneously replace capital taxes, capital moves into JAP, EU and ODC; this result can be explained by the fact that these regions had higher taxes on the use of capital than USA. DAM, DAF and DAS benefit from the replacement of capital taxes in the developed regions, and there is an improvement in their terms of trade.

Let us now consider the replacement of all factor taxes (last two columns of Table 3.6). In this case, the results are dominated by what happens when capital taxes are replaced. When USA, JAP and EU unilaterally replace factor taxes, there is a welfare loss for these regions, accompanied by terms of trade deterioration (0.8%, 2.1% and 1.1%, respectively). These gains are comprised of a reduction in tax exporting of $2.2, $9.3, and $6.2 billion respectively, and $2.1 billion efficiency losses for USA whereas JAP and EU obtain $9.3 and $2.3 billion efficiency gains. These regions attract capital from all other regions. As to developing regions, DAM and DAS benefit from the replacement of the factor taxes in USA (their terms of trade improve 0.5% and 0.3%, respectively). When JAP replaces factor taxes DAM, DAF and DAS obtain welfare gains of $232 million (0.02% of GDP), $158 million (0.05% of GDP), and $3.898 million (0.26% of GDP) respectively; the terms of trade of these developing regions also improve, specially for DAS (0.8%). When EU replaces factor taxes, DAF benefits the most (welfare gains of $828 million, and terms of trade improvement of 1%), followed by DAS and DAM.

When all developed regions simultaneously replace factor taxes, the developing regions that benefit the most are DAF and DAS. DAF obtains a welfare

gain of 1.8% of GDP ($5,909 million) with a very small improvement in terms of trade (0.01%). DAS obtains a welfare gain of $9,334 million (0.6% of GDP) and an improvement of 2.1% in terms of trade. DAM is also better off, but DE is worse off as a result of the deterioration in its terms of trade (0.7%).

In conclusion, when capital is internationally mobile, the results indicate that developed regions export factor taxes (especially on the use of capital) to developing regions, and that the magnitude of the effects depends upon commercial ties; that is USA mainly affects DAM, JAP mainly affects DAS, and EU mainly affect DAF.

Table 3.7 reports the case when import tariffs are replaced by a non distorting tax on final consumption. The regions replacing the tariffs suffer welfare losses and terms of trade worsening. A tariff lowers foreign export prices; the gain depends on the ability of the tariff-imposing country to drive down foreign export prices. Also notice that the effects of the replacement of import tariffs on welfare and terms of trade are larger than when factor taxes are replaced.

When USA, JAP, and EU unilaterally eliminate and replace import tariffs, they suffer welfare losses and terms of trade deterioration. The welfare losses in these regions are due to efficiency losses that more than compensate for the positive tax exporting effect. In this scenario, capital moves out of these regions since this factor is cheaper elsewhere. There is an increase in exports, an increase in imports, a reduction in output for domestic consumption, and a reduction in aggregate consumption. All other regions benefit from the replacement of tariffs, both in terms of welfare and terms of trade improvement. In particular, when USA replaces tariffs DAM's terms of trade improve by 0.8%; when tariffs are replaced in JAP, DAS's terms of trade improve by 0.6%; and, DE and DAF's terms of trade improve by 1.6% and 1.4%, respectively, when EU replaces its tariffs.

Table 3.7: Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs and factor taxes
International Capital Mobility
($ millions)

Replacement	Import tariffs				Import tariffs and factor taxes			
of taxes in:	EV	TEE	DWL	TOT	EV	TEE	DWL	TOT
1. *USA*								
USA	-13,111	20,284	-33,395	-1.81%	-71,718	16,279	-87,997	-2.58%
JAP	2,351	2,885	-534	0.61%	1,374	-2,638	4,012	0.69%
EU	4,402	4,141	261	0.53%	3,538	1,711	1,827	0.51%
ODC	2,216	1,018	1,198	0.32%	3,797	5,959	-2,162	0.67%
DAM	1,483	1,043	440	0.82%	2,165	2,549	-383	1.35%
DAF	658	639	19	0.46%	524	-14	537	0.43%
DAS	1,832	156	1,676	0.41%	2,730	7,875	-5,144	0.67%
DE	337	1,118	-781	0.23%	167	-2,916	3,083	0.17%
Total	167	31,284	-31,117		-57,423	28,803	-86,226	
2. *JAP*								
USA	1,588	1,410	177	0.25%	4,249	4,507	-258	0.76%
JAP	-5,884	7,659	-13,543	-2.03%	-5,547	-2,054	-3,493	-4.08%
EU	1,279	1,052	227	0.15%	2,361	2,453	-92	0.34%
ODC	512	386	126	0.07%	1,219	1,247	-28	0.23%
DAM	240	204	37	0.13%	450	434	16	0.29%
DAF	92	69	22	0.07%	273	274	-1	0.23%
DAS	2,227	1,944	283	0.55%	5,957	5,824	133	1.31%
DE	149	95	54	0.10%	-36	220	-256	0.03%
Total	202	12,820	-12,617		8,925	12,904	-3,978	
3. *EU*								
USA	4,049	3,611	438	0.64%	3,396	3,408	-11	0.57%
JAP	1,855	1,304	550	0.52%	564	831	-267	0.41%
EU	-18,077	30,134	-48,211	-2.06%	-23,661	20,805	-44,466	-3.19%
ODC	3,225	2,426	800	0.46%	9,041	9,032	8	1.64%
DAM	1,157	934	223	0.63%	1,238	1,180	58	0.77%
DAF	2,001	1,515	486	1.39%	2,761	2,468	293	2.48%
DAS	2,571	2,415	156	0.61%	5,210	5,311	-101	1.24%
DE	2,486	2,282	204	1.55%	911	794	117	0.95%
Total	-732	44,621	-45,353		-540	43,830	-44,369	
4. *USA, JAP, EU, ODC*								
USA	-4,050	28,093	-32,143	-0.41%	-1,864	28,375	-30,240	-0.25%
JAP	-587	12,676	-13,263	-0.66%	-1,387	-2,434	1,047	-2.36%
EU	-5,359	40,951	-46,311	-0.62%	-6,977	30,754	-37,732	-1.13%
ODC	-8,202	25,005	-33,208	-1.02%	-9,656	26,271	-35,927	-1.28%
DAM	3,313	2,499	814	1.83%	4,227	4,362	-135	2.69%
DAF	7,628	903	6,725	0.66%	8,789	1,682	7,107	2.20%
DAS	7,619	5,290	2,329	1.79%	16,520	20,447	-3,927	3.93%
DE	3,693	4,233	-540	2.37%	1,425	-1,480	2,905	1.63%
Total	4,055	119,651	-115,596		11,076	107,977	-96,901	

EV: Equivalent Variation; TEE: Tax Exporting Effect; DWL: Deadweight gain (or loss);
TOT: Terms of Trade.
Note: Totals may not add up due to rounding.

When all developed regions replace tariffs simultaneously, all developing regions benefit both in terms of welfare and terms of trade improvement.

The last two columns of Table 3.7 show the joint effects of the replacement of import tariffs and factor taxes. As can be seen, the results are qualitatively the same as when only import tariffs are replaced. Larger welfare losses are observed for developed regions when they unilaterally replace both import tariffs and factor taxes; there are also stronger terms of trade effects. The results are bigger than those obtained when factors are immobile, but are still tariff dominated.

As in the scenario without capital mobility, the effects of the replacement of income taxes were also calculated. Results not reported here indicate that in this case there are small welfare gains (losses) and small terms of trade effects. When USA and EU eliminate income taxes, their welfare improves because of the elimination of a distortion in the economy, and there is also terms of trade improvement. These regions attract capital from the other regions. All other regions are worse off and their terms of trade deteriorate. In the case of JAP, it obtains losses of $194 million (0.006% of GDP) as a result of the terms of trade deterioration (0.1%); capital leaves this region. All other regions benefit, although there are small effects on both welfare and terms of trade. When all developed regions simultaneously replace income taxes, capital moves out of USA, JAP, DAM and DAS. All developing regions and JAP suffer terms of trade deterioration. DAM, DAS and DE also suffer a welfare loss.

The joint effects of the replacement of factor taxes, import tariffs and income taxes were also computed. Results not reported here indicate that the results are dominated by the effects of import tariffs. When USA, JAP and EU replace unilaterally all taxes, the region eliminating the taxes suffers terms of trade deterioration and welfare loss. When all developed regions eliminate all taxes,

developing regions benefit. Lastly, when all regions simultaneously replace all taxes, developed regions benefit since imports tariffs are higher in developing regions; DAF and DE obtain welfare gains.

In summary, when capital is assumed to be internationally mobile, the results suggest that USA, JAP and EU export capital taxes to some particular developing regions. In the case of taxes on the use of labour and income taxes, the results appear to suggest that there is tax exporting from JAP to developing regions, although the effects on both welfare and terms of trade are small. Import tariffs are more important than domestic taxes in their effects on both welfare and terms of trade.

3.5.3 SENSITIVITY ANALYSIS

As indicated earlier on, the elasticities used in the model play a key role in the results. Therefore, it is important to examine how the results of the model change when some of its parameters are changed. I look at the effects of a change in trade elasticities, since they determine the strength of the terms of trade effects associated with policy changes. In particular, the elasticity of substitution between import types (ζ), and the elasticity of substitution between comparable imported and domestically produced goods (υ) are considered. It has been argued that the terms of trade effects increase when the ζ elasticities are smaller and the υ elasticities are larger. In addition, I report on the sensitivity of the results to changes in the elasticity of export transformation (ε).

In the model, the elasticities of substitution used are based on price elasticity estimates, since it was not possible to find econometric estimates of elasticities of substitution for CES demand functions. In the case of the elasticities of export transformation it was not possible to find econometric estimates; hence these

parameters were calculated such that the elasticity of supply was equal to one. The elasticity of transformation indicates the difference among the goods exported to the other seven regions; the larger the elasticity, the more similar are the exported goods and vice-versa. Uniform values for these elasticities of 0.5, 1.5 and 3.0 are used in the sensitivity analysis; the first value is smaller than the one used in the model, whereas the last two values are larger. These elasticity values were chosen in order to consider extreme possibilities, that is very little substitution (or transformation) and almost infinite substitution (or transformation). I focus on the replacement of factor taxes and import tariffs, since these experiments have larger effects on both terms of trade and welfare. The results of the sensitivity analyses are summarised in Tables 3.8 to 3.10.

Sensitivity analysis was not carried out for the case of the elimination of factor taxes when factors are internationally immobile, since in this case the burden of the taxes is borne by the owner of the factor and there is no tax exporting.

Table 3.8 presents the results of the sensitivity analysis for the replacement of import tariffs when factors of production are internationally immobile. First, in the case of trade elasticities, the larger the elasticity ζ (or υ) the smaller the terms of trade deterioration and the welfare loss for the region replacing import tariffs. As to developing regions, as either ζ (or υ) increases there are smaller welfare gains and terms of trade improvement. Once again, the replacement of tariffs in USA affects mainly DAM; in EU affects mainly DAF; and in JAP affects specially DAS. Second, in the case of the export transformation elasticity, as ε increases both welfare losses and terms of trade deterioration reduce for the region replacing import tariffs. As to developing regions, they continue obtaining welfare gains and terms of trade improvement as ε increases. However, some regions benefit more than others; for

example, when JAP eliminates tariffs, DAS's terms of trade improve from 0.81% to 0.85% as ε increases from 0.5 to 3.0; in the case of EU, DAF's terms of trade improve from 2.52% to 3.24%. Overall the findings of the sensitivity analysis are consistent with the results of the central case, i.e. the region replacing the tariffs obtains welfare losses and terms of trade deterioration, whereas other region's welfare and terms of trade improve.

Table 3.8: Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
Factor Immobility

Replacement of taxes in:	Elasticity of substitution between import types ζ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$
1. *USA*						
USA	-21,869	-14,809	-12,475	-3.30	-2.20	-1.84
JAP	1,924	1,667	1,516	0.73	0.64	0.58
EU	5,632	2,947	2,261	0.75	0.39	0.30
ODC	4,583	3,639	3,220	0.81	0.65	0.57
DAM	2,393	2,010	1,778	1.49	1.25	1.10
DAF	1,135	642	505	1.05	0.59	0.46
DAS	2,608	2,141	1,891	0.63	0.51	0.45
DE	532	122	43	0.43	0.10	0.03
Total	-3,062	-1,640	-1,260			
2. *JAP*						
USA	2,374	1,848	1,585	0.40	0.31	0.27
JAP	-7,395	-4,182	-3,256	-3.47	-2.32	-1.99
EU	3,042	1,099	706	0.40	0.15	0.09
ODC	1,530	703	525	0.28	0.13	0.09
DAM	470	270	202	0.29	0.17	0.12
DAF	222	90	56	0.20	0.08	0.05
DAS	3,640	3,197	2,828	0.85	0.77	0.69
DE	251	55	20	0.21	0.04	0.02
Total	4,134	3,080	2,666			
3. *EU*						
USA	5,985	2,655	1,845	0.99	0.44	0.30
JAP	2,138	894	714	0.80	0.33	0.26
EU	-29,644	-20,009	-16,845	-3.86	-2.68	-2.29
ODC	8,617	7,228	6,471	1.54	1.29	1.15
DAM	1,810	1,172	970	1.12	0.71	0.59
DAF	3,563	2,867	2,495	3.29	2.64	2.29
DAS	5,385	3,759	3,216	1.27	0.90	0.77
DE	1,498	1,325	1,176	1.21	1.08	0.95
Total	-647	-109	43			
4. *USA, JAP, EU, ODC*						
USA	-6,327	-5,363	-4,728	-0.90	-0.73	-0.63
JAP	-401	-487	-229	-0.99	-1.01	-0.91
EU	-13,072	-8,212	-6,642	-1.86	-1.24	-1.04
ODC	-11,003	-5,740	-4,552	-1.48	-0.60	-0.41
DAM	5,401	3,652	3,027	3.40	2.27	1.87
DAF	5,884	3,787	3,066	5.47	3.50	2.83
DAS	14,877	10,106	8,456	3.57	2.44	2.05
DE	2,999	1,969	1,608	2.45	1.60	1.31
Total	-1,641	-289	7			

Table 3.8 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
Factor Immobility

Replacement of taxes in:	Elasticity of substitution between domestic and imported products υ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	υ = 0.5	υ = 1.5	υ = 3.0	υ = 0.5	υ = 1.5	υ = 3.0
1. *USA*						
USA	-19,656	-15,938	-14,691	-2.95	-2.38	-2.19
JAP	2,010	1,546	1,368	0.81	0.56	0.46
EU	3,549	3,244	3,241	0.48	0.43	0.42
ODC	4,497	3,683	3,349	0.79	0.66	0.60
DAM	3,344	2,018	1,615	2.06	1.25	1.00
DAF	757	791	806	0.71	0.72	0.72
DAS	3,209	2,552	2,333	0.73	0.61	0.57
DE	149	296	338	0.16	0.27	0.27
Total	-2,140	-1,808	-1,640			
2. *JAP*						
USA	1,918	1,945	1,944	0.33	0.33	0.33
JAP	-5,198	-4,940	-4,938	-2.68	-2.61	-2.64
EU	1,458	1,324	1,333	0.19	0.17	0.17
ODC	814	931	958	0.14	0.17	0.17
DAM	475	316	275	0.29	0.20	0.17
DAF	116	111	106	0.10	0.10	0.09
DAS	3,935	3,660	3,708	0.90	0.87	0.90
DE	80	120	137	0.09	0.11	0.11
Total	3,597	3,468	3,524			
3. *EU*						
USA	3,789	2,854	2,598	0.62	0.47	0.43
JAP	880	1,003	1,048	0.34	0.35	0.34
EU	-27,436	-20,799	-18,605	-3.60	-2.78	-2.52
ODC	9,356	6,462	5,455	1.66	1.16	0.98
DAM	1,822	1,280	1,087	1.10	0.78	0.67
DAF	3,612	2,941	2,741	3.40	2.67	2.44
DAS	5,235	4,381	4,167	1.18	1.04	1.02
DE	1,882	1,576	1,512	2.14	1.43	1.20
Total	-860	-302	3			
4. *USA, JAP, EU, ODC*						
USA	-6,860	-6,269	-5,822	-0.98	-0.88	-0.81
JAP	-897	-899	-1,066	1.07	-1.25	-1.43
EU	-13,182	-9,416	-7,871	-1.86	-1.41	-1.24
ODC	-7,988	-7,407	-7,273	-0.99	-0.88	-0.85
DAM	5,787	4,035	3,403	3.59	2.51	2.13
DAF	4,811	4,274	4,094	4.56	3.91	3.67
DAS	14,004	12,511	12,099	3.22	3.01	2.97
DE	2,751	2,644	2,639	3.14	2.41	2.11
Total	-1,576	-527	203			

Table 3.8 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
Factor Immobility

Replacement of taxes in:	Elasticity of export transformation ε					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	ε = 0.5	ε = 1.5	ε = 3.0	ε = 0.5	ε = 1.5	ε = 3.0
1. *USA*						
USA	-17,387	-16,872	-16,606	-2.60	-2.53	-2.49
JAP	2,049	1,680	1,481	0.78	0.64	0.56
EU	3,926	3,503	3,284	0.53	0.47	0.43
ODC	3,879	4,078	4,181	0.69	0.72	0.74
DAM	1,999	2,204	2,303	1.24	1.37	1.44
DAF	616	824	943	0.56	0.76	0.87
DAS	2,568	2,354	2,258	0.62	0.56	0.54
DE	244	231	223	0.19	0.19	0.18
Total	-2,106	-1,997	-1,933			
2. *JAP*						
USA	2,351	1,904	1,632	0.40	0.32	0.28
JAP	-5,468	-4,823	-4,450	-2.78	-2.55	2.42
EU	1,637	1,406	1,289	0.22	0.19	0.17
ODC	862	917	945	0.16	0.16	0.17
DAM	346	318	302	0.21	0.20	0.19
DAF	150	112	95	0.14	0.10	0.08
DAS	3,375	3,496	3,561	0.81	0.83	0.85
DE	109	91	80	0.09	0.07	0.07
Total	3,363	3,420	3,453			
3. *EU*						
USA	3,563	3,378	3,212	0.59	0.56	0.53
JAP	1,514	929	622	0.57	0.34	0.21
EU	-22,865	-22,476	-22,189	-3.03	-2.99	-2.96
ODC	7,773	7,715	7,673	1.39	1.38	1.37
DAM	1,147	1,364	1,467	0.70	0.84	0.91
DAF	2,739	3,246	3,505	2.52	2.99	3.24
DAS	4,426	4,211	4,118	1.06	1.00	0.97
DE	1,300	1,470	1,573	1.05	1.20	1.28
Total	-404	-163	-19			
4. *USA, JAP, EU, ODC*						
USA	-6,058	-5,891	-5,897	-0.85	-0.82	-0.82
JAP	-406	-696	-833	-0.98	-1.09	1.14
EU	-9,157	-9,644	-9,833	-1.36	-1.42	-1.45
ODC	-6,970	-7,276	-7,466	-0.81	-0.86	-0.88
DAM	3,785	4,245	4,471	2.35	2.65	2.80
DAF	3,908	4,601	4,968	3.60	4.27	4.62
DAS	12,022	11,660	11,514	2.91	2.81	2.76
DE	2,191	2,368	2,478	1.78	1.93	2.03
Total	-684	-633	-597			

Note: Totals may not add up due to rounding.

Let us now consider the scenario when capital is assumed to be internationally mobile. The sensitivity analysis also confirms the results of the model in the sense that there is evidence that USA, JAP and EU export factor taxes to the developing regions with which they have closer commercial ties. Table 3.9 shows that as the elasticity of substitution between import types (ζ) increases, there are less welfare losses and less terms of trade deterioration in USA and EU; the other regions reduce (increase) their welfare gains (losses) and terms of trade improvement (deterioration). In the case of JAP, as ζ increases the welfare losses obtained as a result of the elimination of factor taxes become welfare gains, and the terms of trade deterioration also reduces. In DAF and DAS welfare gains reduce and terms of trade improve less; in DAM the welfare gains become losses and terms of trade deteriorate; and in DE welfare losses increase and terms of trade deteriorate.

The results are qualitatively the same when the elasticity of substitution between comparable imported and domestically produced goods (υ) increases (see Table 3.9).

Let us consider the elasticity of export transformation (ε). In this case, as ε increases, both welfare losses and terms of trade deterioration increase for the regions eliminating the taxes. As to developing regions, as ε increases their welfare losses become welfare gains and their terms of trade improve. The sensitivity analysis confirms the results of the model in the sense that there is evidence of tax exporting of factor taxes from USA, JAP, and EU to the developing regions with which they have close commercial ties (see Table 3.9).

Table 3.9: Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing factor taxes
International Capital Mobility

Replacement of taxes in:	Elasticity of substitution between import types ζ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$
1. *USA*						
USA	-7,403	-2,422	395	-1.26	-0.45	0.00
JAP	-441	-1,144	-1,531	0.20	0.03	-0.06
EU	820	-1,590	-2,900	0.16	-0.11	-0.27
ODC	2,008	1,360	977	0.40	0.30	0.25
DAM	889	664	525	0.62	0.49	0.41
DAF	-5	-189	-308	0.05	-0.09	-0.17
DAS	1,342	580	44	0.35	0.18	0.07
DE	132	-368	-612	0.12	-0.19	-0.34
Total	-2,657	-3,108	-3,410			
2. *JAP*						
USA	3,899	2,058	915	0.70	0.41	0.23
JAP	-5,378	2,915	7,881	-3.43	-1.33	-0.11
EU	3,790	-39	-2,228	0.49	0.05	-0.19
ODC	1,521	239	-537	0.28	0.08	-0.03
DAM	496	103	-118	0.32	0.08	-0.05
DAF	237	117	36	0.22	0.13	0.07
DAS	4,043	3,648	3,232	0.79	0.73	0.68
DE	177	-350	-622	0.15	-0.18	-0.35
Total	8,785	8,690	8,560			
3. *EU*						
USA	1,498	-1,711	-3,452	0.27	-0.23	-0.51
JAP	184	-1,842	-2,950	0.23	-0.25	-0.52
EU	-11,542	-3,343	1,260	-1.76	-0.79	-0.25
ODC	6,596	5,564	4,974	1.27	1.10	1.01
DAM	539	-30	-358	0.38	0.04	-0.15
DAF	1,008	744	575	1.17	0.96	0.83
DAS	3,388	2,265	1,500	0.77	0.53	0.38
DE	-1,302	-1,516	-1,608	-0.49	-0.64	-0.70
Total	370	132	-60			
4. *USA, JAP, EU, ODC*						
USA	2,184	1,676	1,424	0.30	0.21	0.17
JAP	-3,632	966	3,840	2.42	-1.21	-0.46
EU	-2,591	-96	1,519	-0.52	-0.21	-0.00
ODC	-1,791	-451	417	-0.38	-0.13	0.03
DAM	2,223	451	-677	1.53	0.43	-0.27
DAF	6,441	5,524	4,813	0.43	-0.30	-0.87
DAS	11,219	7,686	5,107	2.55	1.75	1.17
DE	-905	-2,617	-3,495	0.01	-1.12	-1.71
Total	13,148	13,139	12,948			

Table 3.9 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing factor taxes
International Capital Mobility

Replacement of taxes in:	Elasticity of substitution between domestic and imported products υ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	υ = 0.5	υ = 1.5	υ = 3.0	υ = 0.5	υ = 1.5	υ = 3.0
1. *USA*						
USA	-7,565	-1,999	1,232	-1.26	-0.40	0.12
JAP	-198	-1,625	-2,511	0.30	-0.11	-0.36
EU	90	-1,974	-3,192	0.08	-0.16	-0.31
ODC	2,264	1,205	708	0.44	0.28	0.21
DAM	1,494	455	-235	0.94	0.37	0.00
DAF	-54	-160	-238	0.02	-0.07	-0.13
DAS	1,685	866	397	0.37	0.24	0.18
DE	-191	-76	-6	-0.03	0.01	0.03
Total	-2,474	-3,308	-3,845			
2. *JAP*						
USA	4,087	1,505	-52	0.73	0.32	0.08
JAP	-3,220	2,600	6,407	-3.18	-1.08	0.39
EU	1,831	126	-845	0.28	0.07	-0.06
ODC	740	730	635	0.16	0.16	0.14
DAM	498	172	-52	0.30	0.13	0.00
DAF	193	139	94	0.19	0.15	0.11
DAS	4,854	3,518	2,486	0.92	0.66	0.44
DE	-146	-101	-78	0.02	-0.00	-0.02
Total	8,837	8,689	8,594			
3. *EU*						
USA	479	-2,272	-3,921	0.11	-0.32	-0.58
JAP	-827	-1,964	-2,619	0.04	-0.31	-0.51
EU	-11,823	-1,637	4,205	-1.82	-0.54	0.23
ODC	7,296	4,631	3,425	1.36	0.96	0.79
DAM	599	-82	552	0.38	0.01	-0.24
DAF	1,229	441	-97	1.36	0.73	0.31
DAS	3,702	2,505	1,728	0.77	0.57	0.44
DE	-411	-1,664	-2,432	0.47	-0.61	-1.26
Total	243	-42	841			
4. *USA, JAP, EU, ODC*						
USA	1,431	881	566	0.18	0.07	-0.01
JAP	-2,962	618	3,062	-2.42	-1.08	-0.12
EU	-4,215	-265	2,131	-0.72	-0.21	0.09
ODC	-1,186	-1,339	-1,369	-0.25	-0.30	-0.33
DAM	2,582	568	-786	1.64	0.54	-0.18
DAF	6,320	5,534	4,994	0.35	-0.28	-0.69
DAS	12,063	8,838	6,654	2.50	1.99	1.63
DE	-723	-1,784	-2,421	0.83	-0.36	-1.04
Total	13,311	13,051	12,832			

Table 3.9 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing factor taxes
International Capital Mobility

Replacement of taxes in:	Elasticity of export transformation ε					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	ε = 0.5	ε = 1.5	ε = 3.0	ε = 0.5	ε = 1.5	ε = 3.0
1. *USA*						
USA	-400	-5,551	-8,375	-0.10	-0.97	-1.44
JAP	-1,316	-787	-502	-0.65	0.13	0.24
EU	-2,278	-268	812	-0.22	0.05	0.19
ODC	1,199	1,787	2,093	0.26	0.37	0.43
DAM	464	815	1,017	0.35	0.58	0.71
DAF	-359	-38	133	-0.26	0.04	0.20
DAS	92	1,218	1,840	0.06	0.32	0.47
DE	-328	-98	74	-0.22	-0.00	0.16
Total	-2,925	-2,922	-2,908			
2. *JAP*						
USA	2,091	2,926	3,391	0.41	0.55	0.63
JAP	4,417	-1,348	-4,524	-0.37	-2.56	-3.74
EU	-232	1,581	2,548	-0.00	0.25	0.38
ODC	-84	997	1,577	0.01	0.21	0.31
DAM	-120	341	612	-0.07	0.23	0.41
DAF	-100	233	409	-0.08	0.23	0.40
DAS	3,496	4,018	4,310	0.67	0.80	0.88
DE	-336	-115	49	-0.22	-0.01	0.14
Total	9,132	8,633	8,372			
3. *EU*						
USA	-2,573	0	1,388	-0.39	0.04	0.28
JAP	-2,123	-966	-351	-0.45	-0.00	0.23
EU	-242	-7,947	-12,155	-0.33	-1.36	-1.92
ODC	5,610	6,037	6,239	1.10	1.18	1.22
DAM	-402	312	721	-0.21	0.25	0.52
DAF	632	883	1,007	0.84	1.09	1.21
DAS	1,498	3,131	4,027	0.33	0.73	0.95
DE	-1,727	-1,349	-1,071	-0.84	-0.50	-0.24
Total	672	101	-195			
4. *USA, JAP, EU, ODC*						
USA	2,432	1,542	1,021	0.34	0.19	0.11
JAP	1,891	-1,526	-3,463	-0.65	-1.96	-2.69
EU	1,124	-1,845	-3,527	-0.03	-0.43	-0.65
ODC	1,514	-1,823	-3,741	0.22	-0.38	-0.72
DAM	-501	1,574	2,780	-0.19	1.14	1.93
DAF	4,334	6,368	7,454	-1.42	0.43	1.43
DAS	5,697	10,419	13,038	1.26	2.39	3.02
DE	-2,780	-1,654	-816	-1.43	-0.41	0.35
Total	13,710	13,056	12,747			

Note: Totals may not add up due to rounding.

Tables 3.10 presents the results of the sensitivity analysis for the replacement of import tariffs, when capital is assumed to be internationally mobile. First, let us consider the elasticity of substitution between import types (ζ). In this case, the losses of the region replacing the tariffs reduce as the elasticity increases; the worsening of the terms of trade also reduces. As to developing regions, when USA is the region replacing tariffs, DAM's welfare gains increase as the elasticity increases (terms of trade remain unaltered); DAF's welfare gains also increase; DAS and DE's welfare gains reduce, with a very small change in terms of trade. When JAP replaces tariffs, there is a small reduction in welfare gains of developing regions as the elasticity increases (terms of trade remain almost unaltered). When EU replaces tariffs, DAF's welfare gains increase as the elasticity increases and terms of trade improve from 1.3% to 1.5%; for all other developing regions, there is a reduction in welfare gains.

Then, let us consider changes in the elasticity of substitution between comparable imported and domestically produced goods (υ) (see Table 3.10). As this elasticity increases, the welfare losses of the region replacing tariffs increase and the terms of trade deteriorate more. Developing regions exhibit increasing welfare gains and improving terms of trade.

Lastly, let us consider changes in the elasticity of export transformation (ε) (see Table 3.10). As ε increases the regions replacing import tariffs exhibit a reduction in welfare losses and in the worsening of their terms of trade. Regarding developing regions, as the exported goods become less differentiated (that is, as ε increases) welfare gains reduce and the improvement in terms of trade also reduce. Overall the results are consistent with the findings of the central case specification.

Table 3.10: Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
International Capital Mobility

Replacement of taxes in:	Elasticity of substitution between import types ζ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$	$\zeta = 0.5$	$\zeta = 1.5$	$\zeta = 3.0$
1. *USA*						
USA	-13,476	-12,883	-12,559	-1.87	-1.78	-1.73
JAP	2,422	2,313	2,256	0.62	0.60	0.60
EU	4,602	4,305	4,145	0.55	0.52	0.51
ODC	2,195	2,234	2,285	0.32	0.32	0.32
DAM	1,467	1,488	1,496	0.82	0.83	0.83
DAF	645	661	653	0.45	0.46	0.46
DAS	1,860	1,806	1,782	0.42	0.40	0.38
DE	433	264	163	0.29	0.19	0.13
Total	149	187	221			
2. *JAP*						
USA	1,592	1,590	1,595	0.25	0.25	0.25
JAP	-6,045	-5,789	-5,631	-2.07	-2.01	-1.97
EU	1,357	1,243	1,177	0.16	0.15	0.14
ODC	513	516	528	0.07	0.07	0.07
DAM	249	233	216	0.14	0.13	0.12
DAF	103	79	52	0.08	0.06	0.04
DAS	2,231	2,221	2,215	0.55	0.54	0.54
DE	184	124	88	0.12	0.08	0.06
Total	183	216	240			
3. *EU*						
USA	4,168	3,993	3,894	0.66	0.63	0.62
JAP	1,964	1,818	1,748	0.54	0.52	0.51
EU	-18,614	-17,749	-17,240	-2.12	-2.02	-1.96
ODC	3,178	3,280	3,376	0.46	0.47	0.47
DAM	1,183	1,128	1,059	0.64	0.61	0.58
DAF	1,897	2,082	2,204	1.32	1.45	1.53
DAS	2,696	2,464	2,303	0.65	0.58	0.54
DE	2,714	2,316	2,083	1.69	1.45	1.32
Total	-815	-669	-573			
4. *USA, JAP, EU, ODC*						
USA	-4,320	-3,885	-3,642	-0.45	-0.38	-0.34
JAP	-305	-744	-997	-0.60	-0.68	-0.72
EU	-5,541	-5,158	-4,885	-0.65	-0.60	-0.56
ODC	-8,867	-7,711	-6,946	-1.11	-0.96	-0.87
DAM	3,369	3,255	3,141	1.87	1.80	1.74
DAF	7,469	7,739	7,887	0.55	0.73	0.84
DAS	7,886	7,380	7,029	1.86	1.73	1.63
DE	4,171	3,335	2,856	2.65	2.16	1.88
Total	3,862	4,211	4,443			

Table 3.10 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
International Capital Mobility

Replacement of taxes in:	Elasticity of substitution between domestic and imported products υ					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	υ = 0.5	υ = 1.5	υ = 3.0	υ = 0.5	υ = 1.5	υ = 3.0
1. *USA*						
USA	-11,964	-14,175	-15,522	-1.67	-1.94	-2.09
JAP	2,085	2,590	2,905	0.57	0.64	0.69
EU	3,738	4,917	5,670	0.45	0.59	0.67
ODC	2,046	2,317	2,407	0.31	0.32	0.31
DAM	1,364	1,613	1,814	0.77	0.88	0.95
DAF	555	750	898	0.40	0.51	0.60
DAS	1,728	1,993	2,171	0.40	0.44	0.45
DE	330	399	427	0.26	0.28	0.29
Total	-118	405	771			
2. *JAP*						
USA	1,317	1,844	2,242	0.21	0.29	0.35
JAP	-4,973	-6,765	-8,204	-1.74	-2.30	-2.74
EU	1,028	1,488	1,787	0.12	0.18	0.21
ODC	451	569	656	0.06	0.08	0.08
DAM	213	268	318	0.12	0.15	0.18
DAF	82	102	123	0.06	0.08	0.09
DAS	1,957	2,490	3,006	0.49	0.61	0.72
DE	143	180	208	0.10	0.12	0.14
Total	219	178	136			
3. *EU*						
USA	3,452	4,664	5,468	0.54	0.73	0.86
JAP	1,568	2,152	2,452	0.46	0.59	0.66
EU	-16,547	-20,086	-22,321	-1.89	-2.26	-2.47
ODC	3,076	3,285	3,221	0.46	0.44	0.38
DAM	1,028	1,311	1,525	0.57	0.70	0.79
DAF	1,823	2,226	2,563	1.30	1.50	1.65
DAS	2,401	2,878	3,266	0.58	0.68	0.75
DE	2,315	2,933	3,394	1.55	1.84	2.05
Total	-884	-637	-432			
4. *USA, JAP, EU, ODC*						
USA	-3,839	-4,204	-4,275	-0.40	-0.41	-0.39
JAP	-290	-891	-1,677	-0.47	-0.83	-1.16
EU	-4,642	-6,889	-8,233	-0.54	-0.79	-0.92
ODC	-8,675	-7,901	-7,636	-1.09	-1.00	-1.01
DAM	3,025	3,644	4,111	1.70	1.99	2.18
DAF	7,311	7,964	8,472	0.48	0.83	1.09
DAS	7,085	8,375	9,435	1.68	1.94	2.13
DE	3,538	4,314	4,840	2.48	2.79	3.01
Total	3,513	4,413	5,037			

Table 3.10 (Continued): Sensitivity Analysis - Welfare and terms of trade effects of an equal-yield tax replacement of existing import tariffs
International Capital Mobility

Replacement of taxes in:	Elasticity of export transformation ε					
	Equivalent Variation $ Millions			Terms of Trade % Change		
	ε = 0.5	ε = 1.5	ε = 3.0	ε = 0.5	ε = 1.5	ε = 3.0
1. *USA*						
USA	-16,652	-12,060	-9,534	-2.37	-1.65	-1.25
JAP	2,816	2,213	1,885	0.79	0.56	0.43
EU	5,939	3,951	2,880	0.74	0.47	0.32
ODC	2,577	2,111	1,861	0.39	0.30	0.26
DAM	1,613	1,442	1,340	0.91	0.80	0.74
DAF	854	601	468	0.64	0.41	0.29
DAS	2,454	1,648	1,205	0.56	0.37	0.26
DE	469	291	161	0.35	0.19	0.07
Total	70	196	266			
2. *JAP*						
USA	1,960	1,473	1,189	0.31	0.23	0.19
JAP	-7,777	-5,318	-3,948	-2.70	-1.83	-1.34
EU	1,912	1,095	659	0.24	0.13	0.07
ODC	782	434	247	0.12	0.06	0.02
DAM	363	202	109	0.21	0.11	0.05
DAF	204	60	-16	0.18	0.04	-0.03
DAS	2,386	2,179	2,061	0.59	0.53	0.50
DE	212	127	66	0.16	0.08	0.02
Total	41	251	367			
3. *EU*						
USA	5,576	3,589	2,473	0.89	0.56	0.38
JAP	2,721	1,602	1,002	0.87	0.42	0.19
EU	-22,663	-16,704	-13,377	-2.62	-1.89	-1.48
ODC	3,582	3,120	2,870	0.53	0.44	0.40
DAM	1,459	1,065	836	0.82	0.57	0.43
DAF	2,167	1,954	1,841	1.55	1.35	1.25
DAS	3,368	2,333	1,757	0.81	0.55	0.41
DE	2,573	2,456	2,372	1.63	1.53	1.46
Total	-1,219	-585	-226			
4. *USA, JAP, EU, ODC*						
USA	-4,934	-3,797	-3,206	-0.56	-0.37	-0.26
JAP	-798	-515	-322	-0.73	-0.64	-0.56
EU	-7,260	-4,779	-3,349	-0.86	-0.55	-0.37
ODC	-8,880	-7,995	-7,482	-1.14	-0.99	-0.90
DAM	4,068	3,081	2,508	2.32	1.68	1.32
DAF	7,783	7,586	7,496	0.79	0.62	0.55
DAS	9,784	6,979	5,445	2.32	1.63	1.25
DE	4,034	3,574	3,245	2.68	2.27	1.97
Total	3,798	4,135	4,335			

Note: Totals may not add up due to rounding.

3.5.4 DIFFERENTIAL FACTOR TAX RATES

From the available data it was not possible to calculate differential tax rates by industry. In reality, in each country there are differential tax rates for each sector in the economy. Hence, given that intersectoral effects may play an important role in tax exporting, it seems interesting to investigate whether the results of the model are altered when there are differential factor tax rates by industry. Appendix 3.2 (Section 5) describes how these differential tax rates were calculated. As an illustration, three counterfactual experiments were carried out: i) elimination and replacement of labour taxes; ii) elimination and replacement of capital taxes; and iii) elimination and replacement of all factor taxes. Each experiment is performed for USA, JAP, and EU individually, and for all developed regions simultaneously (i.e. USA, JAP, EU, and ODC). Similar to the previous experiments, existing factor taxes were replaced by an equal yield non-distorting tax on final expenditure within each region. Tables 3.11 and 3.12 present the results for factor immobility and international capital mobility, respectively.

First, let us consider the scenario where factors of production are internationally immobile (see Table 3.11). As expected, the unilateral replacement of taxes on the use of labour yields a positive equivalent variation for USA, JAP, and EU; this can be due to either the gain in productive efficiency or the removal of consumer distortions brought about by the effects differential taxation has on the price of output. When USA replaces labour taxes, there is a welfare gain of approximately $11 billion (0.2% of GDP) and an improvement of 1.5% in the region's terms of trade; all other regions suffer welfare losses and terms of trade deterioration (among the developing regions, DAM's terms of trade deteriorates the

most, i.e. 0.7%). The terms of trade effects and welfare gains (losses) with differential tax rates are larger than those obtained previously.

When JAP replaces labour taxes, it obtains gains of around $8 billion and its terms of trade improve 2.5%. This result contrasts with the findings of the initial experiment in which JAP lost $307 million and its terms of trade deteriorated (0.2%). In this case, there is an improvement in the terms of trade brought about by the increase in the price of exports as a result of the increase in the price of labour. As a result of the replacement of labour taxes, the price of this factor reduces, specially in the sectors of primary commodities and services that had higher tax rates. Then, demand for the factor increases, driving its price up relative to capital; in consequence the cost of output for both domestic consumption and exports increases, resulting in higher prices. In the benchmark case, the price of labour also increased, but less because of the uniform tax rate. As to developing regions, all lose as a result of the policy change and suffer terms of trade deterioration, specially DAS.

When EU replaces labour taxes, there are very small effects on both welfare and terms of trade. When all developed regions replace labour taxes, all developing regions are worse off as a result of the terms of trade deterioration.

In short, when labour taxes are replaced there are larger welfare gains (losses) and stronger terms of trade effects than in the central case with uniform tax rates. The improvement in terms of trade is brought about by the effect differential taxation has on output prices; in this case, the increase in the price of exports resulted from the increase in the price of labour. These results contrast with earlier findings in which both welfare and terms of trade effects were rather small.

Table 3.11: Welfare and terms of trade effects of an equal-yield tax replacement of factor taxes in the presence of differential tax rates
Factor immobility

Replacement of taxes in:	Taxes on labour		Taxes on capital		All factor taxes	
	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change
1. *USA*						
USA	10,539	1.54	715	0.11	11,290	1.64
JAP	-847	-0.30	-312	-0.13	-1,159	-0.43
EU	-2,501	-0.33	-40	-0.01	-2,542	-0.34
ODC	-2,649	-0.50	76	0.01	-2,576	-0.48
DAM	-1,129	-0.72	-51	-0.04	-1,180	-0.75
DAF	-123	-0.11	-53	-0.05	-175	-0.16
DAS	-1,545	-0.35	-59	-0.03	-1,608	-0.38
DE	-19	-0.02	-66	-0.05	-86	-0.07
Total	1,727		210		1,964	
2. *JAP*						
USA	-2,849	-0.48	3,139	0.52	282	0.05
JAP	7,958	2.52	-6,215	-2.62	1,889	-0.17
EU	-1,530	-0.21	1,775	0.23	244	0.03
ODC	-675	-0.13	697	0.13	16	0.00
DAM	-234	-0.15	237	0.15	6	0.00
DAF	-140	-0.13	144	0.13	6	0.00
DAS	-2,744	-0.64	2,828	0.62	46	-0.01
DE	-67	-0.06	73	0.06	44	0.00
Total	-281		2,678		2,533	
3. *EU*						
USA	-11	0.00	2,187	0.36	2,197	0.36
JAP	5	0.00	642	0.22	647	0.23
EU	139	0.03	-7,714	-1.33	-7,525	-1.31
ODC	-8	-0.00	3,628	0.66	3,615	0.66
DAM	-29	-0.02	406	0.25	378	0.23
DAF	-33	-0.03	743	0.62	709	0.60
DAS	-140	-0.03	2,121	0.46	1,977	0.43
DE	-10	-0.01	514	0.41	501	0.40
Total	-87		2,527		2,499	
4. *USA, JAP, EU, ODC*						
USA	7,522	1.02	7,835	1.29	15,352	2.33
JAP	7,173	2.25	-6,117	-2.64	1,199	-0.46
EU	-4,184	-0.55	-3,334	-0.78	-7,466	-1.32
ODC	-2,690	-0.53	-30	-0.07	-2,695	-0.61
DAM	-1,394	-0.89	708	0.43	-705	-0.47
DAF	-305	-0.27	924	0.77	613	0.51
DAS	-4,480	-1.02	5,348	1.14	798	0.12
DE	-123	-0.11	732	0.59	601	0.48
Total	1,518		6,065		7,698	

Note: Totals may not add up due to rounding.

Turning to the replacement of capital taxes, in the case of USA there is a welfare gain and terms of trade improvement, whereas all other regions are worse off. When JAP and EU replace capital taxes, they obtain welfare losses resulting from terms of trade deterioration (2.6% and 1.3% respectively). All other regions are better off. In this case the results suggest that JAP and EU could be exporting capital taxes specially to DAS in the case of JAP, and to DAF in the case of the EU. The simultaneous replacement of capital taxes in developed regions also benefits developing regions; their terms of trade improve between 0.4% in the case of DAM and 1.1% in the case of DAS. The replacement of capital taxes in the presence of differential taxation generates larger welfare gains and stronger terms of trade effects than in the presence of uniform tax rates.

When all factors taxes are replaced in USA, this region obtains welfare gains and its terms of trade improve; developing regions obtain welfare losses as a result of terms of trade deterioration (especially DAM whose terms of trade deteriorate 0.8%). When all factors taxes are replaced in JAP, there are small welfare and terms of trade effects in all other regions; this result is due to the fact that the replacement of labour taxes generates terms of trade deterioration, and the replacement of capital taxes generates terms of trade improvement of almost the same magnitude. When the EU replaces all factor taxes, the results are dominated by the effects of capital taxes as in the initial findings.

Table 3.12 considers the scenario where capital is assumed to be internationally mobile. The unilateral replacement of labour taxes generates welfare gains for the region replacing the taxes. As to developing regions, there are small losses as a result of the small terms of trade deterioration. However, when all developed regions simultaneously replace labour taxes, EU and ODC obtain welfare

losses; developing countries also obtain welfare losses ranging from 0.1% of GDP in the case of DAM, to 1.3% of GDP in the case of DAF; terms of trade deteriorate 0.9% and 1.6% respectively. In this case there is no tax exporting of labour taxes.

If these results are compared with those obtained in the central case, differential taxation generates larger welfare gains (losses) and stronger terms of trade effects. For example, when USA replaces labour taxes, the region obtains welfare gains of 0.2% of GDP compared with 0.01% of GDP without differential taxation, and the region's terms of trade improve 1.6% compared to 0.1%. As to developing countries, the deterioration in DAM's terms of trade increases from 0.04%, without differential taxation, to 0.8%.

When taxes on the use of capital are replaced, the region replacing the tax obtains welfare losses as a result of terms of trade deterioration. The region also attracts capital because this factor is now cheaper relative to labour. USA appears to be exporting capital taxes to DAM and DAS; JAP and EU export capital taxes to all developing regions but DE. When all developed regions simultaneously replace capital taxes, DAM, DAF and DAS obtain welfare gains of 0.2%, 2.1% and 1% of GDP, respectively, as a result of the terms of trade improvement. Comparing these results with those obtained without differential taxation, little change is observed in the case of USA but for the other regions there are larger welfare gains (losses) and stronger terms of trade effects. For example, in the case of JAP the replacement of capital taxes generates welfare losses of 0.2% of GDP whereas in the central case JAP obtained welfare gains of 0.01% of GDP. JAP has the highest tax rates on the use of capital, and as a result of the elimination of these taxes this country attracts capital from all other regions, increasing the production of manufactured goods and in turn exports. At the same time, imports from all other regions are reduced; hence

the supply of goods for domestic consumption is reduced. There is also a deterioration of JAP's terms of trade (4.4% compared with 1.9% without differential taxation) brought about by the reduction in the price of exports as a result of the reduction in the price of capital.

Lastly, in the presence of differential tax rates, the welfare and terms of trade effects of the elimination of all factor taxes in USA are dominated by labour taxes (which are higher than capital taxes) whereas with uniform tax rates the results are dominated by capital taxes. By contrast, in the case of JAP and EU the results are dominated by capital taxes, as it was the case with uniform tax rates.

Table 3.12: Welfare and terms of trade effects of an equal-yield tax replacement of factor taxes in the presence of differential tax rates
International Capital Mobility

Replacement of taxes in:	Taxes on labour		Taxes on capital		All factor taxes	
	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change	Equivalent Variation $ Millions	Terms of Trade % Change
1. *USA*						
USA	10,550	1.55	-5,006	-0.81	5,947	0.72
JAP	-857	-0.29	-996	0.02	-1,843	-0.27
EU	-2,504	-0.33	-582	0.01	-3,066	-0.31
ODC	-2,627	-0.49	1,897	0.10	-733	-0.08
DAM	-1,176	-0.76	790	0.56	-378	-0.19
DAF	-120	-0.11	-122	-0.05	-238	-0.16
DAS	-1,611	-0.37	862	0.25	-756	-0.11
DE	-15	-0.14	-205	-0.10	-219	-0.11
Total	1,640		-3,361		-1,286	
2. *JAP*						
USA	-2,672	-0.44	5,362	0.91	2,695	0.50
JAP	7,943	2.55	-6,909	-4.39	2,113	-1.98
EU	-1,546	-0.21	2,613	0.37	1,080	0.18
ODC	-691	-0.13	1,449	0.28	749	0.16
DAM	-266	-0.17	481	0.30	228	0.15
DAF	-128	-0.12	2,764	0.26	155	0.16
DAS	-2,957	-0.69	6,750	1.40	3,713	0.74
DE	-45	-0.05	-123	-0.02	-171	-0.06
Total	-362		12,386		10,562	
3. *EU*						
USA	-15	-0.00	1,619	0.26	1,605	0.26
JAP	-5	-0.00	-509	0.12	-514	0.12
EU	56	0.00	-14,279	-2.47	-14,259	-2.47
ODC	85	0.02	9,416	1.80	9,498	1.82
DAM	-19	-0.01	645	0.44	628	0.43
DAF	13	0.03	1,705	1.75	1,718	1.78
DAS	-88	-0.02	4,861	1.11	4,771	1.10
DE	-42	-0.02	-903	-0.14	-945	-0.16
Total	-16		2,555		2,503	
4. *USA, JAP, EU, ODC*						
USA	7,707	1.11	7,990	1.27	16,004	2.38
JAP	7,179	2.30	-6,896	-3.93	1,056	-1.75
EU	-3,165	-0.43	-4,411	-1.11	-8,588	-1.64
ODC	-2,840	-0.57	-2,138	-0.48	-5,105	-1.07
DAM	-1,424	-0.92	2,082	1.41	581	0.46
DAF	4,454	-1.61	7,047	0.89	6,807	0.71
DAS	-4,510	-1.03	14,712	3.35	9,915	2.28
DE	-44	-0.05	-1,162	-0.03	-1,301	-0.13
Total	7,356		17,226		19,368	

Note: Totals may not add up due to rounding.

3.6 CONCLUDING REMARKS

In this chapter I present numerical results on the possibility that developed regions export domestic taxes to developing regions, particularly to those regions with which they have close commercial ties. I have used a general equilibrium model that incorporates domestic taxation and import tariffs of eight regions, chosen to represent world trade. Two variants of the model were considered: in the first one both labour and capital are assumed to be internationally immobile, in the second one capital is internationally mobile.

The results of the model suggest that when factors of production are internationally immobile, the replacement of domestic taxes have almost no effect of welfare and terms of trade; hence there is no tax exporting of domestic taxes to developing regions, which is not surprising, since the burden of the taxes is borne by the same factors. In the case of JAP, the expected results are obtained, in the sense that the elimination of factor taxes generates both welfare gains and terms of trade improvement in developing regions, but the effects on both welfare and terms of trade appear small. Income taxes have a rather small impact on welfare and terms of trade. It was also observed that in some cases the replacement of domestic taxes and/or import tariff had a negative effect on welfare. This may occur because the adverse terms of trade effects are strong enough that the removal of distorting domestic taxes could lead to reductions in national welfare.

When capital is assumed to be internationally mobile, the results support the existence of tax exporting of capital taxes by USA, JAP and EU to some particular developing regions. In the case of taxes on the use of labour and income taxes, the results indicate that there is tax exporting from JAP to developing regions, although

the effects on both welfare and terms of trade are small. In this case, once again, import tariffs are more important than domestic taxes in their effects on both welfare and terms of trade.

The effects that differential factor tax rates might have on the results of the model were also considered. Stronger terms of trade effects and larger welfare gains (losses) were found, and this confirms that intersectoral effects are very important for tax exporting. In particular, more taxes could be exported if a region taxes more heavily those industries that constitute their main exports, as appear to be the case of capital taxes in JAP and EU.

It is not possible to say that policies in developed regions affect all developing regions in the same way. Policies will have stronger effects on those regions with which there are close commercial ties; for example, USA will mainly affect DAM, JAP will mainly affect DAS, and EU will mainly affect DAF and to a lesser extent DE.

In the light of these results, it could be suggested that the possibility of tax exporting of domestic taxes will become a more important part in trade negotiations as international markets become more integrated. Capital markets are becoming more international in scope; international migration is highly constraint and very selective; hence it will still take considerable time to reduce restrictions to labour mobility. At the moment, tariffs are low in developed countries and the benefits of any further reductions could be dampened by higher domestic factor taxes, which can be exported to developing countries.

Appendix 3.1: Model equations and notation

Production side of the model

- Value-added function

$$Q_i^r = \gamma_i^r [\delta_i^r L_i^{r\,(\sigma_i^r-1)/\sigma_i^r} + (1-\delta_i^r) K_i^{r\,(\sigma_i^r-1)/\sigma_i^r}]^{\sigma_i^r/(\sigma_i^r-1)} \qquad [A3.1]$$

- Domestic and foreign sales

$$Q_i^r = \varphi_i^r [\beta_i^r DC_i^{r\,(\rho_i^r-1)/\rho_i^r} + (1-\beta_i^r) EXP_i^{r\,(\rho_i^r-1)/\rho_i^r}]^{\rho_i^r/(\rho_i^r-1)} \qquad [A3.2]$$

- Export allocation

$$EXP_i^r = \nu_i^r \left(\sum_s \theta_i^r RX_i^{r,s\,(\varepsilon_i^r-1)/\varepsilon_i^r} \right)^{\varepsilon_i^r/(\varepsilon_i^r-1)}, \; s \neq r \qquad [A3.3]$$

Demand side of the model

- Utility function

$$U^r = \left(\sum_{i=1}^{3} (\alpha_i^r)^{1/\mu^r} (X_i^r)^{(\mu^r-1)/\mu^r} \right)^{\mu^r/(\mu^r-1)} \qquad [A3.4]$$

- Domestic and import consumption

$$CMP_i^r = \Omega_i^r \left(\omega_i^r IMP_i^{r\,(\omega_i^r-1)/\omega_i^r} + (1-\omega_i^r) DOM_i^{r\,(\omega_i^r-1)/\omega_i^r} \right)^{\omega_i^r/(\omega_i^r-1)} \qquad [A3.5]$$

- Import allocation

$$IMP_i^r = \psi_i^r \left(\sum_s \chi_i^r DIMP_i^{r,s\,(\zeta_i^r-1)/\zeta_i^r} \right)^{\zeta_i^r/(\zeta_i^r-1)}, \; s \neq r \qquad [A3.6]$$

Constraints

- Consumer budget constraint ($I^r = E^r$)

$$P_{L,r}\bar{L}_r + P_{K,r}\bar{K}_r + TR^r + TB^r = \sum_{i=1}^{3} P_i^r X_i^r + T^r \qquad [A3.7]$$

- Government budget constraint

$$TR^r = t^r\left(P_{L,r}\overline{L^r} + P_{K,r}\overline{K^r}\right) + \sum_{i=1}^{3}\tau_i^r P_{M,i}^r IMP_i^r + t_{C,i}^r\sum_{i=1}^{3}P_{i,r}X_i^r + t_{K,i}^r\sum_{i=1}^{3}P_{K,r}K_i^r + t_{L,i}^r\sum_{i=1}^{3}P_{L,r}L_i^r \quad [A3.8]$$

- Trade balance equation

$$\sum_{i=1}^{3}P_{M,i}^{r^*}IMP_i^r + TB^r = \sum_{i=1}^{3}P_{X,i}^r EXP_i^r \text{, where } TB^r = TB_0^r\left(\sum_{i=1}^{3}P_{i,r}X_i^r\right)\left(\sum_{i=1}^{3}P_{i,r}^0X_i^r\right)^{-1} \quad [A3.9]$$

Zero profit conditions

In each region the value of domestic output in sector i must be equal to the capital and labour costs of producing good i. At the same time, the value of domestic output in sector i equals the value of commodities sold in the domestic market plus the value of commodities sold as exports. Combining these two zero profit conditions, the following expression is obtained:

$$P_{DC,i}^r DC_i^r + P_{X,i}^r EXP_i^r = P_{K,i}^r K_i^r + P_{L,i}^r L_i^r . \quad [A3.10]$$

The value of commodities sold as exports must equal the value of the sum of exports to the other 7 regions:

$$P_{X,i}^r EXP_i^r = \sum_s P_{RX,i}^{r,s} RX_i^{r,s}, \; s \neq r \quad [A3.11]$$

The value of total imports must equal the value of the sum of imports from the other 7 regions:

$$P_{M,i}^r IMP_i^r = \sum_s P_{DIMP,i}^{r,s} DIMP_i^{r,s}, \; s \neq r \quad [A3.12]$$

The value of the composite commodity i demanded by consumers must equal the value of aggregate imports plus the value of domestically produced goods:

$$P_{i,r}CMP_i^r = P_{M,i}^{r^*}IMP_i^r + P_{DOM,i}^r DOM_i^r \quad [A3.13]$$

The value of goods sold for domestic consumption must be equal to the value of the demand for domestically produced goods; i.e.,

$$P^r_{DC,i} DC^r_i = P^r_{DOM,i} DOM^r_i .$$

Hence:

$$P^r_{DC,i} = P^r_{DOM,i} \qquad [A3.14]$$

The value of exports from region r to region s must be equal to the value of imports of region s from region r; i.e.,

$$P^{r,s}_{RX,i} RX^{r,s}_i = P^{s,r}_{DIMP,i} DIMP^{s,r}_i .$$

Hence:

$$P^{r,s}_{RX,i} = P^{s,r}_{DIMP,i} \qquad [A3.15]$$

Market clearing conditions

- Goods markets

The supply of goods for domestic consumption must equal the demand for domestically produced goods:

$$DC^r_i = DOM^r_i \qquad [A3.16]$$

Exports from region r to region s must equal imports of region s from region r because there are assumed to be no transfer (e.g. transport) costs in shipping goods from one region to another:

$$RX^{r,s}_i = DIMP^{s,r}_i \qquad [A3.17]$$

Total supply of composite commodities, which consists of the composite of similar domestic products and aggregate imports, must equal consumer's demand in each region:

$$CMP^r_i = X^r_i \qquad [A3.18]$$

- Factor markets

For labour:

$$\sum_{i=1}^{3} L^r_i = \overline{L_r} \qquad [A3.19]$$

For capital, assuming that it is internationally immobile, the market clearing condition is:

$$\sum_{i=1}^{3} K_i^r = \overline{K_r} \qquad \text{[A3.20]}$$

When capital is internationally mobile, the market clearing condition becomes:

$$\sum_{i=1}^{3}\sum_{r=1}^{8} K_i^r = \sum_{r=1}^{8} \overline{K}_r \qquad \text{[A3.20a]}$$

Equations for price relationships

- Import prices

$$P_{M,i}^{r^*} = P_{M,i}^r\left(1+\tau_i^r\right) \qquad \text{[A3.21]}$$

- Factor prices

$$P_{K,i}^r = P_{K,r}\left(1+t_{K,i}^r\right) \qquad \text{[A3.22]}$$

$$P_{L,i}^r = P_{L,r}\left(1+t_{L,i}^r\right) \qquad \text{[A3.23]}$$

- Consumer prices

$$P_i^r = P_{i,r}\left(1+t_{C,i}^r\right) \qquad \text{[A3.24]}$$

List of variables

Q_i^r Value added good i region r.

L_i^r Labour input good i region r.

K_i^r Capital input good i region r.

DC_i^r Output for domestic consumption good i region r.

EXP_i^r Output for exports good i region r.

$RX_i^{r,s}$ Exports of good i from region r to region s.

U^r Consumer utility region r.

X_i^r Consumer demand good i region r.

CMP_i^r Total supply of good i region r.

IMP_i^r Total imports good i region r.

DOM_i^r Domestic output for domestic for consumption good i region r.

$DIMP_i^{r,s}$ Imports good i region r from to region s.

I^r Income region r.

E^r Expenditure region r

TR^r Government transfers region r.

TB^r Trade surplus or deficit region r.

T^r Income tax paid by consumers region r.

$P_{L,r}$ Selling prices of labour region r.

P_L^r Producer price labour input good i region r.

$P_{K,r}$ Selling prices of capital region r.

P_K^r Producer price capital input good i region r.

$P_{i,r}$ Gross price of consumer good i region r.

P_i^r Price paid by consumers for good i region r.

$P_{M,i}^{r^*}$ Domestic price of imports good i region r.

$P_{M,i}^r$ Gross price of imports good i region r.

$P_{X,i}^r$ Price of exports good i region r.

$P_{DC,i}^r$ Price goods sold for domestic consumption good i region r.

$P_{RX,i}^{r,s}$ Price of good i exported from region r to region s.

$P^{r}_{DOM,i}$ Price good i for domestic consumption region r.

$P^{r,s}_{DIMP,i}$ Price of good i imported by region r from region s.

List of parameters

γ^{r}_{i} Scale parameter value added function, good i region r.

δ^{r}_{i} Share parameter value added function, good i region r.

σ^{r}_{i} Elasticity of substitution between labour and capital, good i region r.

φ^{r}_{i} Scale parameter exports and domestic sales function, good i region r.

β^{r}_{i} Share parameter exports and domestic sales function, good i region r.

ρ^{r}_{i} Elasticity of transformation between domestic output, good i region r.

ν^{r}_{i} Scale parameter export allocation function, good i region r.

θ^{r}_{i} Share parameter export allocation function, good i region r.

ε^{r}_{i} Elasticity of transformation between regional exports, good i region r.

α^{r}_{i} Share parameter utility function, good i region r.

μ^{r} Elasticity of substitution in consumption region r.

Ω^{r}_{i} Scale parameter domestic and import consumption function, good i region r.

ω^{r}_{i} Share parameter domestic and import consumption function, good i region r.

υ^{r}_{i} Elasticity of substitution between domestic and imported consumption, good i region r.

ψ^{r}_{i} Scale parameter import allocation function, good i region r.

χ^{r}_{i} Share parameter import allocation function, good i region r.

ζ^{r}_{i} Elasticity of substitution between regional imports, good i region r.

$\overline{L}_r$ Endowment of labour region r.

$\overline{K}_r$ Endowment of capital region r.

t^r Tax rate on income region r.

τ_i^r Tax rate on imports good i region r.

$t_{C,i}^r$ Tax rate on consumption good i region r.

$t_{K,i}^r$ Tax rate on capital (i.e. corporate and property taxes) region r.

$t_{L,i}^r$ Tax rate on labour (i.e. payroll tax and social security contributions) region r.

TB_0^r Benchmark region's trade surplus or deficit region r.

Appendix 3.2: Benchmark data set

The benchmark data set involves both domestic data and external sector data for the following regions: the United States (USA), Japan (JAP), the European Union (EU), Other Developed Countries (ODC), Developing America (DAM), Developing Africa (DAF), Developing Asia (DAS), and Developing Europe (DE). Domestic activity data consists of data on value added by component by industry and domestic taxes. External sector data includes foreign trade and import tariffs. The data set is consistent with 1990 US dollar GDP for the eight regions, as reported by the World Tables (World Bank, 1995).

1. Value added by industry (including net indirect taxes)

First, GDP for each region was taken from the World tables published by the World Bank(1995); then, National Accounts Statistics (United Nations, 1996) were used to obtain the cost components of value added, that is compensation of employees, gross operating surplus and net indirect taxes. In addition, this source was used to split domestic production among primary commodities, manufactured goods and services.

National accounts classify products, based on the international standard industrial classification (ISIC) of the United Nations, in nine broad categories. Primary commodities correspond to the first two categories, that is agriculture, hunting, forestry and fishing, and mining and quarrying. Manufactured goods include all the manufacturing sector. And services comprise the remaining six categories, that is electricity, gas and water; construction; wholesale and retail trade, restaurants and hotels; transport, storage and communications; finance, insurance, real state and business services; community, social and personal services; and government services.

Given that these data are published in domestic currency, average exchange rates (as taken from the International Financial Statistics from the International Monetary Fund) are used to convert the data into US dollars.

Since there is no data on the distribution of value added by industry, nor on the cost components of value added by industry for every country, data on the countries for which this information was available were used. The EU is represented by all member states but Belgium, Greece and Ireland (for Portugal the latest available data was used, that is 1989). Regarding ODC, the distribution of value added by industry was obtained using information for Australia, Austria, Canada, Finland, Iceland, Israel, New Zealand, Norway, South Africa, Sweden, and Switzerland. Then, to calculate the cost components of value added by industry information for Australia, Canada, Finland, Iceland, New Zealand, and Norway was used.

In the case of DAM, ECLAC (1997) provided information on the distribution of value added by industry. As to the cost components of value added, data for Colombia, Ecuador and Venezuela were used. Regarding DAF, the distribution of value added by industry was obtained using information for Cameroon, Egypt, Kenya and Nigeria. Then, to calculate the cost components of value added by industry data for Nigeria were used. With regard to DAS, the distribution of value added by industry was calculated using data for India, Indonesia, Iran, Korea, the Philippines, and Thailand. To calculate the cost components of value added by industry data for Korea, Thailand and India were used. Finally, as to DE, the region's distribution of value added by industry was calculated using data for Hungary, Malta, Poland, Romania, and Turkey; the cost components of value added by industry were obtained

using information for Hungary. It is worth mentioning that in all cases the data were scaled for consistency with the 1990 GDP at factor cost by region.

2. Foreign Trade

The basic sources used are the UNCTAD's 1995 Handbook of International Trade and Development Statistics (Annex A – Network of world exports by selected commodity classes and regions of origin and destination), the United Nation's 1996 National Accounts Statistics, the Balance of Payments Yearbook (International Monetary Fund, 1996), and ECLAC (1997).

To begin with, a commodity classification compatible with the one used for value added was found. In this case, UNCTAD's classification of primary commodities (including fuels) and manufactured products was chosen. The former includes the SITC divisions 0, 1, 2, 3, 4, and 68, whereas the latter includes the SITC divisions 5, 6 (excluding 68), 7, and 8. To represent trade flows export figures were used, since the same value of exports and imports must appear for each region on any bilateral trade route. Exports figures are f.o.b.

For USA and JAP total exports of goods and services were obtained from national accounts. UNCTAD's data were used to split exports of goods between primary commodities and manufactured goods. As to the destination of the regions' exports UNCTAD's data were also used. For services, the same percentage distribution of exports of goods was assumed.

Regarding the EU, from the national accounts for each member state total exports of goods and services were obtained; however, it was not possible to disaggregate exports of goods between primary commodities and manufactured goods. Information from UNCTAD was used. Then, intra-EU trade was subtracted in

order to avoid double counting. This information was obtained from UNCTAD for primary commodities and manufactured goods; EUROSTAT (1994) provided the relevant information on intra-EU trade in services (approximately 48.7% of total exports of services). Then exports of services were adjusted to eliminate this type of trade. Now, regarding the destination of EU exports, UNCTAD's data (Annex A) for primary commodities and manufactured goods were used. As to exports of services, they were calculated using the same percentage distribution of total exports of goods.

With regard to the ODC, from national accounts total exports of goods and services were obtained. Using UNCTAD's data, exports of goods were split between primary commodities and manufactured goods, and intra-regional trade was eliminated. Regarding services, it was assumed that 12.2% of exports were intra-regional trade (this figure corresponds to the weighted average of intra-regional trade of primary commodities and manufactured goods). As to the destination of ODC's exports UNCTAD's data were used. For services, it was assumed the same percentage distribution of exports of goods.

In the case of DAM, data on total exports of goods and services were obtained from ECLAC (1997). Information from national accounts for Ecuador, Guatemala, Mexico, Nicaragua, Panama, Surinam, Uruguay, and Venezuela, was used to split total exports between goods and services. UNCTAD data were used to split exports of goods between primary commodities and manufactured goods, and to eliminate intra-regional trade. Regarding services, it was assumed that 13.7% corresponded to intra-regional trade (this figure is the weighted average of intra-regional trade of primary commodities and manufactured goods). As to the destination of the region's exports, UNCTAD's data were used. For services, the same percentage distribution of exports of goods was assumed.

The Balance of Payments Statistics Yearbook (International Monetary Fund, 1996) was used to obtain data on total exports of goods and services for DAF, DAS, and DE. UNCTAD's data were used to split exports of goods between primary commodities and manufactured goods and to eliminate intra-regional trade.[19] Regarding services, it was assumed that 5.9%, 34.8% and 35.2% of total exports corresponded to intra-regional trade for DAF, DAS, and DE respectively (these figures correspond to the weighted average of intra-regional trade of primary commodities and manufactured goods). As to the destination of the regions' exports, UNCTAD's data were used. For services, once again the same percentages distribution of exports of goods were assumed.

3. Domestic Taxes and Import Tariffs

Regarding domestic taxes, six taxes were included: income tax, corporate tax, property tax, payroll tax, social security contributions, and taxes on goods and services. The average tax rates used in the model were reported in Table 3.2. These rates were calculated as tax revenues divided by the base of the tax. Tax revenues were taken from the Government Finance Statistics Yearbook (International Monetary Fund, 1996).[20] The base of the income tax was total income from factor ownership; in the case of the corporate and the property taxes, the tax base was total use of capital; and in the case of the payroll tax and the social security contributions the tax base was total payments to labour. For taxes on the use of capital as well as

[19] In the case of DAS, UNCTAD's data were adjusted since Turkey and Cyprus are included in Asia. In the case of DE, UNCTAD's data were adjusted to include Eastern Europe, Turkey, Cyprus, Malta and the former Yugoslavia.

[20] These data are collected on a fiscal year basis, and may not coincide with the calendar year used to collect data on production and trade.

on the use of labour, it is assumed that the same tax rate applies across industries, since it was not possible to find the required data.

For the EU and ODC information for all the countries in the region was used to calculate the tax rates. For DAM, DAF, DAS, and DE, the following countries were used to calculate the tax rates in the following way: in each region, the aggregate tax base for the countries available was calculated; then, using the corresponding aggregate tax revenues (for each tax) average tax rates were calculated. The countries used in each region were:

DAM

Income Tax	Costa Rica, Peru, Uruguay, and Venezuela
Corporate Tax	Costa Rica, Ecuador, Paraguay, Peru, Uruguay, and Venezuela
Property Tax	Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, and Uruguay
Payroll Tax	Mexico, Paraguay, and Uruguay
Social Security Contributions	Chile, Costa Rica, Mexico, Peru, Uruguay, and Venezuela

DAF

Income Tax	Cameroon, Egypt, Namibia, Tunisia, and Zimbabwe
Corporate Tax	Cameroon, Namibia, and Zimbabwe
Property Tax	Cameroon, Kenya, Namibia, and Zimbabwe
Payroll Tax	Cameroon, Kenya, Namibia, and Zimbabwe
Social Security Contributions	Cameroon, Kenya, Namibia, and Zimbabwe

DAS

Income Tax	Korea, Thailand, Iran, India, Indonesia, Philippines, Jordan, and Malaysia
Corporate Tax	Korea, Thailand, Iran, India, Philippines, and Jordan
Property Tax	Korea, Thailand, Iran, India, Philippines, and Jordan
Payroll Tax	Korea, Thailand, Iran, India, Philippines, and Jordan
Social Security Contributions	Korea, Thailand, Iran, India, Philippines, and Jordan

DE

Income Tax	Cyprus, Estonia, Malta, Poland, Romania, and Turkey
Corporate Tax	Estonia, Malta, Poland, Romania, and Turkey
Property Tax	Estonia, Malta, Poland, Romania, and Turkey
Payroll Tax	Estonia, Malta, Poland, Romania, and Turkey
Social Security Contributions	Estonia, Malta, Poland, Romania, and Turkey

Regarding taxes on domestic goods and services, these are included in indirect taxes which were calculated as a component of value added. Using information from national accounts different average tax rates were calculated for primary commodities, manufactured products and services (see Table 3.2 in the text).

Finally, import tariffs were taken from GATT-Trade Policy Review (various countries) and correspond to average tariffs for the agricultural and industrial sectors.

For EU information for all member states was used; for ODC, DAM, DAF, DAS, and DE average tariffs were calculated using information for the following countries:

ODC Australia, Austria, Canada, Finland, Iceland, Norway, Sweden, Switzerland, South Africa, and New Zealand

DAM Argentina, Brazil, Colombia, Mexico, and Uruguay

DAF Egypt[21], Ghana, Morocco, Nigeria, and Tunisia

DAS Bangladesh, Indonesia, Korea, Thailand, and the Philippines

DE Czech Republic, Hungary, Poland, Romania, and Slovak Republic

It was assumed that import tariffs on services were equal to zero.

4. Final Demand

The model assumes that there is a representative consumer by region, which simplifies the calculation of final demand. In the case of domestically produced goods, final demand is equal to gross output minus exports; for imported goods, final demand equals imports.

Once all the data were collected, the benchmark data set was assembled in the form of social accounting matrices (SAMs), one matrix for each region. A SAM is a square matrix that contains data for a particular period (usually a year) to offer an empirical description of the economy (see e.g. King, 1985; Pyatt, 1988). In the matrix each element has the following economic interpretation: on the one hand, it is a receipt for the account represented by the row; on the other hand, it is also an expenditure for the account specified by the column. Furthermore, a SAM has the

[21] Egyptian tariffs were very high for Beverages and Spirits (1,247.1%).

property that row and column totals must be equal. This characteristic, according to Pyatt (1988), is associated to the so-called "fundamental law of Economics", which states that each income has its corresponding expenditure.

SAMs comprise accounts for institutions, factors of production, production activities, commodities and the rest of the world. In particular, the SAMs presented in Tables A3.1 to A3.8 comprise two factor accounts (i.e. labour and capital); three production activities (i.e., primary commodities, manufactured goods, and services); three value added accounts, where each one is associated with its correspondent production activity; fifteen commodity accounts that comprise three accounts for exports, three for domestically produced goods, three for imports, and three for composite commodities; one account for domestic institutions, namely the representative consumer; seven accounts for taxes; and seven accounts for the rest of the world (ROW) (one for each of the regions with which there is trade).

The account for factors of production indicates that factor income (measured along the rows) is generated by production activities that hire production factors in order to produce commodities. On the other hand, this income is allocated (across the columns) to domestic institutions (in this case the representative consumer), which are the owners of the factors of production.

The production side of the economy consists of production activities and commodity accounts. Production activities derive their income from output sales to commodity markets (along the rows); at the same time, along the columns it is observed that production activities hire factor services to generate value added, part of which represents factor payments. The remainder accrues to domestic institutions as taxes.

In the commodity accounts, the sources of demand are final consumption and exports (along the rows). These demands can be satisfied by domestic production of goods and services as well as imports. However, it is worth noting that since demand is valued at market prices, taxes on commodities need to be added to express the aggregate supply in the same terms. The importance of the distinction between production activities and commodity accounts, is the fact that it permits us to consider the domestic demand for commodities as a composite of imported and domestically produced goods.

The account for domestic institutions (i.e. the representative consumer) shows that income (along the row) originates from factor services and tax revenues. The column presents the way in which consumer's income is spent on consumption and taxes on consumption.

The accounts for indirect taxes indicate that production activities are the source of indirect taxes (along the rows). The columns indicate that these tax revenues accrue to domestic institutions.

The last accounts of the matrices present the transactions between the domestic economy and the rest of the world. In particular, each domestic economy receives income from the ROW in the form of payments for exports. On the other hand, each domestic economy pays to the ROW for imports. The model assumes that the trade balance in each region remains constant in real terms, so that it was not necessary to adjust the data to obtain a zero external sector balance. The consumer account is not balanced, but the imbalance in each region is equal to the trade balance with the opposite sign. This implies that if a region is in trade surplus, then consumer's expenditure in that region will be greater than consumer's income.

Table A3.1: Benchmark data set - United States
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities													Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I - T	C - T	P - T	PR - T	SSC	Ind - T	M - T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			60.8	683.1	2,569.7																																	3,313.6
Capital			136.0	272.3	1,344.4																																	1,752.7
VA-PC						211.9																																211.9
VA-MG							1,049.2																															1,049.2
VA-S								4,286.0																														4,286.0
ACT-PC									90.7			121.1																										211.9
ACT-MG										307.2			742.0																									1,049.2
ACT-S											150.6			4,135.4																								4,286.0
EXP-PC																																0.0	21.2	19.2	10.7	2.4	19.2	3.2	14.8	90.7
EXP-MG																																0.0	29.1	79.5	44.1	4.1	53.9	1.4	95.2	307.2
EXP-S																																0.0	19.0	37.4	20.7	2.5	27.6	1.7	41.6	150.6
DOM-PC																		121.1																					121.1
DOM-MG																			742.0																				742.0
DOM-S																				4,135.4																			4,135.4
IMP-PC																					119.9																		119.9
IMP-MG																						372.1																372.1
IMP-S																							108.9																108.9
OWN-PC																					121.1																		121.1
OWN-MG																						742.0																742.0
OWN-S																							4,135.4																4,135.4
CMP-PC																								248.3															248.3
CMP-MG																								1,162.8															1,162.8
CMP-S																								4,586.7															4,586.7
CONS	3,313.6	1,752.7																							466.9	93.7	11.5	0.0	375.5	398.3	32.5								6,644.7
I - T			7.3	14.6	71.9																			466.9															466.9
C - T			0.9	1.8	8.8																																		93.7
P - T			0.0	0.0	0.0																																		11.5
PR - T			6.9	77.4	291.2																																		0.0
SSC																																							375.5
Ind - T																					7.3	48.7	342.3																398.3
M - T															14.3	18.2	0.0																						32.5
USA															0.0	0.0	0.0																						0.0
JAP															1.1	87.8	11.5																						100.4
EU															13.0	84.5	33.3																						130.8
DAM															23.6	16.5	12.8																						52.9
DAF															16.5	0.8	4.0																						21.3
DAS															12.8	73.1	15.6																						101.4
DE															1.5	2.3	1.2																						5.0
ODC															37.1	88.9	30.6																						156.6
T - B																															31.1	-5.3	-22.6	12.3	0.7	-1.3	5.0	19.9
TOTAL	3,313.6	1,752.7	211.9	1,049.2	4,286.0	211.9	1,049.2	4,286.0	90.7	307.2	150.6	121.1	742.0	4,135.4	119.9	372.1	108.9	121.1	742.0	4,135.4	248.3	1,162.8	4,586.7	6,464.6	466.9	93.7	11.5	0.0	375.5	398.3	32.5	0.0	100.4	130.8	52.9	21.3	101.4	5.0	156.6	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commodities	CMP-PC	Composite primary commodities	Ind - T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MG	Domestic production manufactured goods	CMP-MG	Composite manufactured goods	M- T	Import tariffs	T - B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I - T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C - T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P - T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MG	Own consumption manufactured goods	PR - T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.2: Benchmark data set - Japan
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities															Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I - T	C - T	P - T	PR - T	SSC	Ind - T	M - T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			19.1	426.8	1,165.9																																		1,611.8
Capital			53.3	292.8	777.0																																		1,123.2
VA-PC						82.6																																	82.6
VA-MG							829.1																																829.1
VA-S								2,239.0																															2,239.0
ACT-PC									7.0			75.6																											82.6
ACT-MG										272.9			556.2																										829.1
ACT-S											36.3			2,202.7																									2,239.0
EXP-PC																																1.1	0.0	0.6	0.1	0.0	4.8	0.1	0.3	7.0
EXP-MG																																87.8	0.0	52.2	9.5	3.8	91.8	3.0	24.9	272.9
EXP-S																																11.5	0.0	6.8	1.2	0.5	12.5	0.4	3.3	36.3
DOM-PC																		75.6																					75.6
DOM-MG																			556.2																					556.2
DOM-S																				2,202.7																				2,202.7
IMP-PC																					105.6																			105.6
IMP-MG																						94.3																		94.3
IMP-S																							51.4																	51.4
OWN-PC																					75.6																			75.6
OWN-MG																						556.2																		556.2
OWN-S																							2,202.7																	2,202.7
CMP-PC																								183.1																	183.1
CMP-MG																								743.3																	743.3
CMP-S																								2,367.0																	2,367.0
CONS	1,611.8	1,123.2																							168.6	127.4	19.3	0.0	269.1	207.6	13.4									3,540.3
I - T			6.1	33.2	88.1																			168.6																168.6
C - T			0.9	5.0	13.3																																		127.4
P - T			0.0	0.0	0.0																																		19.3
PR - T			3.2	71.2	194.6																																		0.0
SSC																																							269.1
Ind - T																					2.0	92.8	112.9																207.6
M - T															9.0	4.4	0.0																						13.4
USA															21.2	29.1	19.0																						69.3
JAP															0.0	0.0	0.0																						0.0
EU															4.1	24.9	9.9																						38.9
DAM															5.5	1.1	2.1																						8.7
DAF															2.0	0.1	0.5																						2.5
DAS															42.7	25.9	12.4																						81.0
DE															1.9	0.7	0.8																						3.4
ODC															19.3	8.3	6.7																						34.3
T - B																																-31.1		-20.7	-2.2	-1.8	-28.1	-0.2	5.8	-78.3
TOTAL	1,611.8	1,123.2	82.6	829.1	2,239.0	82.6	829.1	2,239.0	7.0	272.9	36.3	75.6	556.2	2,202.7	105.6	94.3	51.4	75.6	556.2	2,202.7	183.1	743.3	2,367.0	3,462.0	168.6	127.4	19.3	0.0	269.1	207.6	13.4	69.3	0.0	38.9	8.7	2.5	81.0	3.4	34.3	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commodities	CMP-PC	Composite primary commodities	Ind - T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MC	Domestic production manufactured goods	CMP-MG	Composite manufactured goods	M - T	Import tariffs	T - B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I - T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C - T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P - T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MC	Own consumption manufactured goods	PR - T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.3 Benchmark data set - European Union
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities													Taxes							Rest of the World							
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I-T	C-T	P-T	PR-T	SSC	Ind-T	M-T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	------1
VaDom			69.6	894.5	2,064.8																																
DepSoS			585.9	417.6	1,788.2																																
VA-PC						236.1																															
VA-MG							1,571.3																														
VA-S								4,555.4																													
ACT-PC									76.0			160.1																									
ACT-MG										450.4			1,120.9																								
ACT-S											179.9			4,375.6																							
EXP-PC																																					
EXP-MG																																					
EXP-S																																13.0	4.1	0.0	3.5	8.3	12.2	4.8	30.2	76.0
DOM-PC																																84.5	24.9	0.0	22.5	35.1	86.8	25.4	171.2	450.4
DOM-MG																																33.3	9.9	0.0	8.9	14.0	33.8	10.3	68.8	179.9
DOM-S																		160.1																				
IMP-PC																			1,120.9																			
IMP-MG																				4,375.6																	
IMP-S																		224.6			361.3		134.5														
OWN-PC																		160.1			1,120.9																
OWN-MG																							4,375.6														
OWN-S																								404.6														
CMP-PC																								1,648.4														
CMP-MG																								4,984.2														
CMP-S	3,116.5	2,273.5																																				
I - T																								450.0	143.7	47.9	5.8	775.3	656.2	47.8								
C - T			9.3	26.4	108.6																			458.0														
P - T			3.1	8.8	36.6																																
PR - T			0.1	2.7	4.6																																
SSC			15.1	222.5	537.7																																
M - T																																					
M - T																					19.9	166.2	470.1														
USA															29.3	18.5	0.0																				
JAP															19.2	79.5	37.4																				
EU															0.6	52.2	6.9																				
DAM															0.0	0.0	0.0																				
DAF															19.7	6.0	8.2																				
DAS															46.8	8.5	12.7																				
DE															22.0	50.1	13.8																				
ODC															30.9	26.9	17.6																				
T - B															56.1	119.6	42.7																				
																																5.3	20.7	0.0	-0.9	9.9	-47.7	34.9	-51.9	-29.6
TOTAL	3,116.5	2,273.5	236.1	1,571.3	4,555.4	236.1	1,571.3	4,555.4	76.0	450.4	179.9	160.1	1,120.9	4,375.6	224.6	361.3	134.5	160.1	1,120.9	4,375.6	404.6	1,648.4	4,984.2	7,487.3	450.0	143.7	47.9	5.8	775.3	656.2	47.8	136.1	59.6	0.0	34.0	68.8	85.2	75.4	218.3	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commodities	CMP-PC	Composite primary commodities	Ind - T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MG	Domestic production manufactured goods	CMP-MG	Composite manufactured goods	M - T	Import tariffs	T - B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I - T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C - T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P - T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MG	Own consumption manufactured goods	PR - T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.4: Benchmark data set - Other Developed Countries
Billion US Dollars

	Factor		Value Added Accounts			Production			Commodities												Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I-T	C-T	P-T	PR-T	SSC	Ind-T	M-T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			41.4	221.0	906.9																																		1,169.4
Capital			111.8	103.3	395.4																																		610.5
VA-PC						166.8																																	166.8
VA-MG							357.7																																357.7
VA-S								1,437.3																															1,437.3
ACT-PC									136.0			30.8																											166.8
ACT-MG										261.6			96.1																											357.7
ACT-S											96.6			1,340.7																										1,437.3
EXP-PC																																37.1	19.3	56.1	1.9	2.3	16.0	3.2	0.0	136.0
EXP-MG																																88.9	8.3	119.6	6.1	4.5	24.2	10.1	0.0	261.6
EXP-S																																30.6	6.7	42.7	1.9	1.7	9.8	3.2	0.0	96.6
DOM-PC																		30.8																					30.8
DOM-MG																			96.1																					96.1
DOM-S																				1,340.7																				1,340.7
IMP-PC																					92.0																			92.0
IMP-MG																						349.1																	349.1
IMP-S																							132.1																132.1
OWN-PC																					30.8																		30.8
OWN-MG																						96.1																	96.1
OWN-S																							1,340.7																1,340.7
CMP-PC																								126.9																126.9
CMP-MG																								461.0																461.0
CMP-S																								1,646.0																1,646.0
CONS	1,169.4	610.5																																						2,351.1
I-T																								163.5	38.6	9.5	10.9	123.0	193.1	32.7										163.5
C-T			7.1	6.5	25.0																																			38.6
P-T			1.7	1.6	6.1																																			9.5
PR-T			0.4	2.1	8.4																																			10.9
SSC			4.4	23.3	95.4																																			123.0
Ind-T																					4.1	15.8	173.2																	193.1
M-T															7.8	24.9	0.0																							32.7
USA															14.8	95.2	41.6																							151.6
JAP															0.3	24.9	3.3																							28.5
EU															30.2	171.2	68.8																							270.2
DAM															16.1	1.8	5.7																							23.6
DAF															4.0	0.7	1.1																							5.8
DAS															6.1	21.1	4.9																							32.1
DE															12.6	9.3	6.7																							28.6
ODC															0.0	0.0	0.0																							0.0
T-B																																-5.0	-5.8	51.9	13.7	-2.7	-17.9	12.1	0.0	46.3
TOTAL	1,169.4	610.5	166.8	357.7	1,437.3	166.8	357.7	1,437.3	136.0	261.6	96.6	30.8	96.1	1,340.7	92.0	349.1	132.1	30.8	96.1	1,340.7	126.9	461.0	1,646.0	2,397.4	163.5	38.6	9.5	10.9	123.0	193.1	32.7	151.6	28.5	270.2	23.6	5.8	32.1	28.6	0.0	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	**DOM-PC**	Domestic production primary commodit	**CMP-PC**	Composite primary commodities	**Ind-T**	Indirect taxes	**ODC**	Other Developed Countries
VA-MG	Value added manufactured goods	**DOM-MG**	Domestic production manufactured good	**CMP-MG**	Composite manufactured goods	**M-T**	Import tariffs	**T-B**	Trade balance
VA-S	Value added services	**DOM-S**	Domestic services	**CMP-S**	Composite services	**USA**	United States		
ACT-PC	Activity account primary commodities	**IMP-PC**	Imports primary commodities	**CONS**	Representative consumer	**JAP**	Japan		
ACT-MG	Activity account manufactured goods	**IMP-MG**	Imports manufactured goods	**I-T**	Income tax	**EU**	European Union		
ACT-S	Activity account services	**IMP-S**	Imports services	**C-T**	Corporate tax	**DAM**	Developing America		
EXP-PC	Exports primary commodities	**OWN-PC**	Own consumption primary commodities	**P-T**	Property tax	**DAF**	Developing Africa		
EXP-MG	Exports manufactured goods	**OWN-MG**	Own consumption manufactured goods	**PR-T**	Payroll tax	**DAS**	Developing Asia		
EXP-S	Exports services	**OWN-S**	Own consumption services	**SSC**	Social security contributions	**DE**	Developing Europe		

Table A3.5: Benchmark data set - Developing America
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities													Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I-T	C-T	P-T	PR-T	SSC	Ind-T	M-T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			34.8	77.6	279.2																																	391.6
Capital			100.7	161.5	410.6																																	672.8
VA-PC						145.3																																145.3
VA-MG							256.7																															256.7
VA-S								742.0																														742.0
ACT-PC									76.1			69.2																										145.3
ACT-MG										29.6			227.1																									256.7
ACT-S											33.7			708.4																								742.0
EXP-PC																		69.2																				76.1
EXP-MG																			227.1																			29.6
EXP-S																				708.4																		33.7
DOM-PC																					27.4																	69.2
DOM-MG																						111.5																227.1
DOM-S																							36.7															708.4
IMP-PC																					69.2																	27.4
IMP-MG																						227.1																111.5
IMP-S																							708.4															36.7
OWN-PC																								101.8															69.2
OWN-MG																								362.9															227.1
OWN-S																								775.6															708.4
CMP-PC																									2.3	33.9	10.4	1.9	33.5	60.0	24.4								101.8
CMP-MG																								2.3															362.9
CMP-S																																						775.6
CONS	391.6	672.8																																				1,230.7
I-T			5.1	8.1	20.7																																	2.3
C-T			1.6	2.5	6.3																																	33.9
P-T			0.2	0.4	1.3																																	10.4
PR-T			3.0	6.6	23.9																																	1.9
SSC																																						33.5
Ind-T																																						60.0
M-T															4.6	19.8	0.0				5.1	24.3	30.5															24.4
USA															10.7	44.1	20.7																					75.5
JAP															0.1	9.5	1.2																					10.8
EU															3.5	22.5	8.9																					34.9
DAM															0.0	0.0	0.0																					0.0
DAF															0.9	0.1	0.2																					1.2
DAS															2.8	4.9	1.4																					9.1
DE															3.0	4.5	2.3																					9.8
ODC															1.9	6.1	1.9																					9.9
T-B																																22.6	2.2	0.9	0.0	-1.1	-0.8	1.9	-13.7	11.8
TOTAL	391.6	672.8	145.3	256.7	742.0	145.3	256.7	742.0	76.1	29.6	33.7	69.2	227.1	708.4	27.4	111.5	36.7	69.2	227.1	708.4	101.8	362.9	775.6	1,242.5	2.3	33.9	10.4	1.9	33.5	60.0	24.4	75.5	10.8	34.9	0.0	1.2	9.1	9.8	9.9	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commoditi	CMP-PC	Composite primary commodities	Ind-T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MG	Domestic production manufactured good	CMP-MG	Composite manufactured goods	M-T	Import tariffs	T-B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I-T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C-T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P-T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MG	Own consumption manufactured goods	PR-T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.6: Benchmark data set - Developing Africa
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities														Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I-T	C-T	P-T	PR-T	SSC	Ind-T	M-T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			8.5	12.6	49.8																																	70.9
Capital			120.1	23.0	96.6																																	239.6
VA-PC						137.0																																137.0
VA-MG							38.1																															38.1
VA-S								156.8																														156.8
ACT-PC									76.1			60.9																										137.0
ACT-MG										12.5			25.6																									38.1
ACT-S											20.4			136.4																								156.8
EXP-PC																																16.5	2.0	46.8	0.9	0.0	3.4	2.5	4.0	76.1
EXP-MG																																0.8	0.1	8.5	0.1	0.0	1.8	0.6	0.7	12.5
EXP-S																																4.0	0.5	12.7	0.2	0.0	1.2	0.7	1.1	20.4
DOM-PC																		60.9																					60.9
DOM-MG																			25.6																				25.6
DOM-S																				136.4																			136.4
IMP-PC																					32.0																		32.0
IMP-MG																						73.1																	73.1
IMP-S																							23.3																23.3
OWN-PC																					60.9																		60.9
OWN-MG																						25.6																	25.6
OWN-S																							136.4																136.4
CMP-PC																								93.3																93.3
CMP-MG																								105.0																105.0
CMP-S																								159.8																159.8
CONS	70.9	239.6																																						310.5
I-T																								5.0	14.4	0.8	0.4	5.7	7.0	28.1										61.4
C-T			7.2	1.4	5.8																			5.0																5.0
P-T			0.4	0.1	0.3																																			0.8
PR-T			0.0	0.1	0.3																																			0.4
SSC			0.7	1.0	4.0																																			5.7
Ind-T																					0.4	6.4	0.1																	7.0
M-T															11.2	16.9	0.0																							28.1
USA															2.4	4.1	2.5																							9.0
JAP															0.0	3.8	0.5																							4.3
EU															8.3	35.1	14.8																							58.1
DAM															1.0	0.8	0.6																							2.4
DAF															0.0	0.0	0.0																							0.0
DAS															5.1	4.7	1.8																							11.5
DE															1.7	3.2	1.5																							6.3
ODC															2.3	4.5	1.7																							8.5
T-B																																-12.3	1.8	-9.9	1.1	0.0	5.2	2.6	2.7	-8.7
TOTAL	70.9	239.6	137.0	38.1	156.8	137.0	38.1	156.8	76.1	12.5	20.4	60.9	25.6	136.4	32.0	73.1	23.3	60.9	25.6	136.4	93.3	105.0	159.8	363.2	5.0	14.4	0.8	0.4	5.7	7.0	28.1	9.0	4.3	58.1	2.4	0.0	11.5	6.3	8.5	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commodities	CMP-PC	Composite primary commodities	Ind-T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MG	Domestic production manufactured goods	CMP-MG	Composite manufactured goods	M-T	Import tariffs	T-B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I-T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C-T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P-T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MG	Own consumption manufactured goods	PR-T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.7: Benchmark data set - Developing Asia
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities													Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I - T	C - T	P - T	PR - T	SSC	Ind - T	M - T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			64.8	95.4	374.2																																	
Capital			354.1	143.6	381.5																																	
VA-PC						450.6																																
VA-MG							253.1																															
VA-S								795.2																														
ACT-PC									96.3			354.4																										
ACT-MG										186.5			66.6																									
ACT-S											51.3			743.9																								
EXP-PC																																						
EXP-MG																															12.8	42.7	22.0	2.8	5.1	0.0	4.7	6.1	96.3
EXP-S																															73.1	25.9	50.1	4.9	4.7	0.0	6.7	21.1	186.5
DOM-PC																															15.6	12.4	13.1	1.4	1.8	0.0	2.1	4.9	51.3
DOM-MG																		354.4																				354.4
DOM-S																			66.6																			66.6
IMP-PC																				743.9																		743.9
IMP-MG																					87.2																	87.2
IMP-S																						356.7																356.7
OWN-PC																							92.9															92.9
OWN-MG																					354.4																	354.4
OWN-S																						66.6																66.6
CMP-PC																							743.9															743.9
CMP-MG																								443.3															443.3
CMP-S																								473.4															473.4
CONS	534.4	879.1																						899.3															899.3
I - T																									19.5	67.2	8.7	1.6	7.8	114.3	104.2								1,736.9
C - T			27.1	11.0	29.2																			19.5															19.5
P - T			3.5	1.4	3.8																																		67.2
PR - T			0.2	0.3	1.1																																		8.7
SSC			1.0	1.4	5.5																																		1.6
Ind - T																																							7.8
M - T																					1.8	50.0	62.5																114.3
USA															21.8	82.4	0.0																						104.2
JAP															19.2	53.9	27.6																						100.7
EU															4.8	91.8	12.5																						109.1
DAM															12.2	86.8	33.8																						132.9
DAF															4.4	3.1	2.4																						9.9
DAS															3.4	1.8	1.2																						6.3
DE															0.0	0.0	0.0																						0.0
ODC															5.3	12.8	5.5																						23.7
T - B															16.0	24.2	9.8																						50.1
																															-0.7	28.1	47.7	0.8	-5.2	0.0	10.1	17.9	98.7
TOTAL	534.4	879.1	450.6	253.1	795.2	450.6	253.1	795.2	96.3	186.5	51.3	354.4	66.6	743.9	87.2	356.7	92.9	354.4	66.6	743.9	443.3	473.4	899.3	1,835.6	19.5	67.2	8.7	1.6	7.8	114.3	104.2	100.7	109.1	132.9	9.9	6.3	0.0	23.7	50.1	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commodities	CMP-PC	Composite primary commodities	Ind - T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MC	Domestic production manufactured goods	CMP-MG	Composite manufactured goods	M- T	Import tariffs	T - B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I - T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C - T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P - T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MC	Own consumption manufactured goods	PR - T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

Table A3.8: Benchmark data set - Developing Europe
Billion US Dollars

	Factors		Value Added Accounts			Production			Commodities													Taxes							Rest of the World								
	Labour	Capital	VA-PC	VA-MG	VA-S	ACT-PC	ACT-MG	ACT-S	EXP-PC	EXP-MG	EXP-S	DOM-PC	DOM-MG	DOM-S	IMP-PC	IMP-MG	IMP-S	OWN-PC	OWN-MG	OWN-S	CMP-PC	CMP-MG	CMP-S	CONS	I-T	C-T	P-T	PR-T	SSC	Ind-T	M-T	USA	JAP	EU	DAM	DAF	DAS	DE	ODC	TOTAL
Labour			143.0	207.9	466.5																																	
Capital			102.0	83.9	315.6																																	
VA-PC						256.5																																
VA-MG							306.4																															
VA-S								819.1																														
ACT-PC									56.9			199.6																										
ACT-MG										59.8			246.5																								
ACT-S											35.5			783.6																							
EXP-PC																																1.5	1.9	30.9	3.0	1.7	5.3	0.0	12.6
EXP-MG																																2.3	0.7	26.9	4.5	3.2	12.8	0.0	9.3
EXP-S																																1.2	0.8	17.6	2.3	1.5	5.5	0.0	6.7
DOM-PC																		199.6																				
DOM-MG																			246.5																			
DOM-S																				783.6																	
IMP-PC																					28.0																
IMP-MG																						52.9															
IMP-S																							20.4														
OWN-PC																					199.6																
OWN-MG																						246.5															
OWN-S																							783.6														
CMP-PC																								236.3														
CMP-MG																								311.8														
CMP-S																								809.7														
CONS	817.4	501.6																							38.9	16.6	0.2	16.9	29.4	26.8	9.2								
I-T																								38.9														
C-T			3.4	2.8	10.4																																	
P-T			0.1	0.0	0.2																																	
PR-T			2.9	4.3	9.6																																	
SSC			5.1	7.5	16.8																																	
Ind-T																																						
M-T																					8.7	12.4	5.8															
USA															3.8	5.4	0.0																					
JAP															3.2	1.4	1.7																					
EU															0.1	3.0	0.4																					
DAM															4.8	25.4	10.3																					
DAF															5.6	0.4	1.9																					
DAS															2.5	0.6	0.7																					
DE															4.7	6.7	2.1																					
ODC															0.0	0.0	0.0																					
T-B															3.2	10.1	3.2																					
																																1.3	0.2	-34.9	-1.9	-2.6	-10.1	0.0	-12.1
TOTAL	817.4	501.6	256.5	306.4	819.1	256.5	306.4	819.1	56.9	59.8	35.5	199.6	246.5	783.6	28.0	52.9	20.4	199.6	246.5	783.6	236.3	311.8	809.7	1,396.8	38.9	16.6	0.2	16.9	29.4	26.8	9.2	6.3	3.5	40.5	7.9	3.8	13.5	0.0	16.6	

Note: Row and column totals may not be equal to the sum of their components because of rounding.

VA-PC	Value added primary commodities	DOM-PC	Domestic production primary commoditi	CMP-PC	Composite primary commodities	Ind-T	Indirect taxes	ODC	Other Developed Countries
VA-MG	Value added manufactured goods	DOM-MC	Domestic production manufactured good	CMP-MG	Composite manufactured goods	M-T	Import tariffs	T-B	Trade balance
VA-S	Value added services	DOM-S	Domestic services	CMP-S	Composite services	USA	United States		
ACT-PC	Activity account primary commodities	IMP-PC	Imports primary commodities	CONS	Representative consumer	JAP	Japan		
ACT-MG	Activity account manufactured goods	IMP-MG	Imports manufactured goods	I-T	Income tax	EU	European Union		
ACT-S	Activity account services	IMP-S	Imports services	C-T	Corporate tax	DAM	Developing America		
EXP-PC	Exports primary commodities	OWN-PC	Own consumption primary commodities	P-T	Property tax	DAF	Developing Africa		
EXP-MG	Exports manufactured goods	OWN-MC	Own consumption manufactured goods	PR-T	Payroll tax	DAS	Developing Asia		
EXP-S	Exports services	OWN-S	Own consumption services	SSC	Social security contributions	DE	Developing Europe		

5. Modification of factor tax rates

The model assumes that the same tax rate applies across industries, as it was not possible to find the required data. Since intersectoral effects may be important for tax exporting, the data set was modified in order to illustrate the relevance of differential factor tax rates by industry. Whalley (1980a, Table 1, p. 1182) presents model-equivalent ad valorem tax rates on the uses of capital and labour for the United States, the European Union, and Japan, by industry (i.e. agriculture and food; raw materials and extractive; non-durable manufacturing; durable manufacturing; and services). The first two industries were associated to what I referred to as primary commodities, the following two industries to manufactured products, and the last industry to services (these tax rates are for 1973).

Tax rates on the uses of capital and labour by industry were calculated, such that they generate the same tax revenues as in the benchmark data set, and that the ratios between the tax rates for manufactures and services, and for manufactures and primary commodities, are the same as those obtained from Whalley (1980a). The resulting tax rates are presented in Table A3.9.

Table A3.9: New ad valorem factor tax rates by industry (%)

	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
1. Taxes on the use of capital								
Primary commodities	2.8	9.5	4.4	4.3	3.5	4.3	5.4	1.9
Manufactured goods	7.8	21.7	19.2	18.8	9.8	12.1	14.9	5.3
Services	6.0	10.0	6.2	6.0	6.1	7.5	9.3	3.3
2. Taxes on the use of labour								
Primary commodities	14.0	21.2	32.7	14.8	10.2	9.7	2.0	6.3
Manufactured goods	6.7	10.2	24.6	11.1	8.9	8.4	1.7	5.5
Services	12.5	19.0	25.1	11.4	8.9	8.4	1.7	5.5

Source: Author's own calculations.

For USA, JAP and EU, the ratios obtained from Whalley (1980a) for each region were used. For taxes on the use of labour in JAP the same proportion as in USA were used, since in Whalley's paper the same tax rate applies for all sectors. For ODC the ratios calculated for the EU were used, and for the developing regions, the ratios were calculated using the average of tax rates for USA, JAP and EU.

Appendix 3.3: Armington elasticities in the model

These elasticities are the elasticity of substitution between comparable imported and domestically produced goods (υ), and the elasticity of substitution between imports forming import composites (ζ). The former was set equal to literature estimates of import price elasticities. The latter was set equal to literature estimates of export price elasticities. Within each region the same values are assumed for all commodity-substitution possibilities.

- For USA and JAP these elasticities were obtained from Marquez (1990).
- For EU these elasticities correspond to the averages of the elasticities of the following countries (sources in parentheses): Belgium-Luxembourg, Denmark, France, Ireland, Italy and the Netherlands (Stern et al, 1976); Germany and the United Kingdom (Marquez, 1990); and Portugal (Houthakker and Magee, 1969).
- For ODC these elasticities correspond to the averages of the elasticities of the following countries (sources in parentheses): Canada (Marquez, 1990); Austria, Finland, Norway, Sweden, Switzerland, Australia, and New Zealand (Stern et. al., 1976).
- For DAM these elasticities correspond to the averages of the elasticities of Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru and Uruguay, as taken from Khan (1974).[22]
- For DAF these elasticities correspond to the averages of the elasticities of Ghana and Morocco, as taken from Khan (1974).

[22] The export price elasticity of Uruguay is not included in the computation of the average elasticity for DAM since it was not available.

- For DAS these elasticities correspond to the averages of the elasticities of the following countries (sources in parentheses): India, the Philippines and Sri Lanka (Khan, 1974); and Pakistan and Bangladesh (Nguyen and Bhuyan, 1977).[23]
- Lastly, for DE I use the elasticities for Turkey estimated by Khan (1974).

The elasticities used in the model are presented in Table 3.3 in the text.

[23] The export price elasticity of the Philippines is not included in the computation of the average elasticity for DAS since it was not available.

CHAPTER 4

EFFICIENCY GAINS FROM THE ELIMINATION OF GLOBAL RESTRICTIONS ON LABOUR MOBILITY: AN ANALYSIS USING A MULTIREGIONAL CGE MODEL

4.1 INTRODUCTION

The purpose of this chapter is to compute the world-wide efficiency gains from the elimination of global restrictions on labour mobility. To this end, a multiregional general equilibrium model is used, since this approach constitutes an ideal framework to analyse the effects of policy changes on resource allocation, the structure of distribution, and economic welfare. In addition, a segmented labour market is considered, since the benefits (losses) of migration are not equally distributed within each country.

The classic economic argument in favour of labour migration is that people move in search of higher wages, hence increasing their own productivity.[1] However, as indicated by Layard et al (1992), the decision to migrate also depends upon other economic, social and political considerations. Among the economic aspects, migrants may take into account comparative wage levels, actual and expected; comparative unemployment rates and unemployment benefits; the availability of housing; and the cost of migration which includes travel expenses, information costs, and the

[1] Layard et al (1992) indicate that free trade and international capital mobility can also raise productivity, without labour migration.

psychological cost of leaving friends and family. Weyerbrock (1995) also indicates that political instability and civil war may cause larger emigration flows than economic or demographic pressures.

Recent empirical studies on international migration have mainly focused on U.S.-Mexico migration patterns (Hill and Méndez 1984, Robinson et al. 1993, and Levy and van Wijnbergen 1994), and migration flows from Eastern Europe and the former Soviet Union into Western Europe (Layard et al 1992, and Weyerbrock 1995).

Hamilton and Whalley (1984) has been the only attempt to quantify the efficiency gains from the removal of global restrictions on labour mobility. They use a partial equilibrium framework, in which the parameters of a CES production function are estimated for a seven-region country classification.[2] Then, the estimated parameters are used to calculate the changes in labour allocation across regions after the removal of immigration controls. They assume that the world-wide labour supply is fixed, that full employment occurs in all regions, and that differences in labour's marginal product across regions arise from barriers to inward mobility of labour in high wage countries. Hamilton and Whalley find large efficiency gains from the removal of immigration controls; in most cases, these gains exceed world-wide GNP generated in the presence of the controls. In addition, in labour exporting regions wage rates rise and capital owners are made worse off; on the other hand, in labour receiving regions wage rates fall and capital owners are made better off.

In contrast to Hamilton and Whalley (1984), I use a multiregional general equilibrium model instead of a partial equilibrium approach, since the former provides an ideal framework to analyse the links among the different regions, and the

[2] The regions considered are: the United States, Japan, the European Union (9-member EU), other developed countries, OPEC, newly industrialised countries and less developed countries.

distributional and welfare effects of migration. The distinctive feature of my analysis is that it considers a segmented labour market, which can be justified on the grounds that this factor of production is not homogeneous. In particular, two types of labour are considered, namely skilled and unskilled. The segmentation of the labour market jointly with the general equilibrium framework allow us to examine the distributional effects of migration between skilled and unskilled labour in each region, and between these two and capital. In addition to that, there are further elaborations on the structure of the model, as I also consider the role of transaction costs, international capital mobility, and selective labour mobility (the latter corresponding to the case where the individuals of a particular developing region are allowed to migrate to developed regions).

According to the results, the elimination of global restrictions on labour mobility generates world-wide efficiency gains that could be of considerable magnitude, ranging from 14% to 62% of world GDP. With the introduction of a segmented labour market, welfare gains reduce since the benefits and losses of migrations are not evenly distributed within each country, ranging from 12% to 55% of world GDP. And when only skilled labour migrates, world-wide efficiency gains are much smaller, since skilled labour represents a small fraction of the labour force in developing regions, ranging from 3% to 11% of world GDP. Lastly, the removal of global restrictions on labour mobility leads to an improvement in global income distribution, as measured by the Gini coefficient. In the benchmark case, the calculated coefficient was 0.41; once the restrictions on labour mobility were eliminated this coefficient reduced, suggesting an improvement in the global distribution of income (the coefficient varied within the range 0.30 to 0.37, depending on the measure of wages used).

The chapter proceeds as follows. Section 2 describes the structure of the multiregional general equilibrium model. Section 3 contains the empirical implementation, which includes the description of the benchmark data set, the calibration of the model, and the specification of elasticities. Section 4 presents the results of the model as well as the sensitivity analysis. Section 5 presents model elaborations, including transaction costs, international capital mobility, and selective mobility. Section 6 offers some concluding remarks.

4.2 THE MODEL

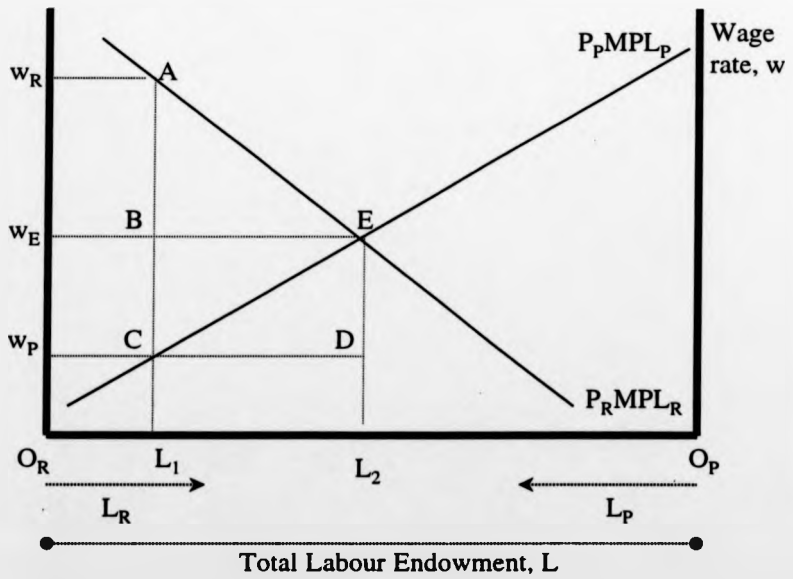
4.2.1 INTRODUCTION

In a world economy characterised by countries with different levels of income, individuals have incentives to migrate to countries with higher wage rates. If labour were allowed to move from one country to another without restrictions, it will do so until the marginal product of labour is the same in both low income and high income countries. In order to assess the benefits and losses from migration, let us consider, drawing on earlier work by Bhagwati and Srinivasan (1983) and Layard et al (1992) on international migration, a world economy consisting of a rich country and a poor country. The wage rate in the rich country is higher than the wage rate in the poor country, and for simplicity it is also assumed that there is no unemployment.

Figure 4.1 shows the distribution of the world labour force, **L**, between the rich country and the poor country. Before migration is allowed, the labour force is larger in the poor country, as measured by the horizontal distance between O_P and L_1, while the labour force in the rich country is given by the distance between O_R and L_1. The wage differential between the rich and the poor countries corresponds to the

vertical distance W_R-W_P. Once barriers to labour movements are removed, labour will move out of the poor country and into the rich country, so that the new equilibrium is reached at point **E**, where wage rates are equalised. Migration will reduce the labour force in the poor country, leading to an increase in wages from W_P to W_E,[3] and a reduction in the demand for labour from O_P-L_1 to O_P-L_2. In addition, migration leads to a process of factor reallocation within the poor country: the remaining workers gain through higher wages, but capital owners lose since labour is now scarce relative to capital.

Figure 4.1: The effects of migration



[3]The magnitude of the increase will depend on the elasticity of labour demand. The more elastic the demand for labour, the smaller the increase in wages.

Conversely, in the rich country the labour force increases from $\mathbf{O_R}$-$\mathbf{L_1}$ to $\mathbf{O_R}$-$\mathbf{L_2}$, which leads to a reduction in the wage rate (assuming no rigidities) from $\mathbf{W_R}$ to $\mathbf{W_E}$. This lower wage will increase the demand for labour and aggregate employment. During the transition, workers will lose through lower wages and capital owners will gain since labour is now less scarce relative to capital. In sum, the loses in the poor country are given by the triangle **CDE**, whereas the rich country gains are given by the triangle **ABE**. Migrants gain the rectangle **BECD**, and since they may send remittances back home, the poor country's losses might be partially or totally compensated. The world economy gains the Harberger triangle **ACE**. It is worth bearing in mind that the preceding analysis was based on the assumption that labour is a homogeneous factor of production, which implies that the benefits and loses of migration are evenly distributed within each country. However, as the analysis will show later on, this is not necessarily the case since there are many types of labour.

At this point it is worth mentioning that for some trade theorists, the issue of the removal of restrictions on labour mobility may not be of great relevance because of the factor price equalisation theorem, according to which factor prices will be equalised by free trade without internationally mobile factors.[4] This theorem, however, is based on very restrictive assumptions: identical technologies in different countries, constant returns to scale, perfect competition, no factor intensity reversals, no specialisation, and that good prices are equalised as a result of trade. Moreover, factor price equalisation depends on the complete convergence of the price of the goods. In reality, the prices of the goods are not fully equalised because of both natural (e.g., transportation costs) and artificial barriers to trade (e.g., import tariffs,

[4] See Samuelson (1948, 1949) for a presentation of the first complete statement of the factor price equalisation theorem. This theorem has been extended and refined by other authors.

import quotas, voluntary export restraints). An additional reason why factor price equalisation may not be achieved is that countries exhibit different technologies and resources, so that they are unlikely to remain unspecialised (Layard and Walters 1978, Krugman and Obstfeld 1994). For example, Burfisher et al (1994) indicate that in the case of the United States and Mexico, the assumption of identical technologies in all sectors, differing only in aggregate factor proportions, is not a realistic one since observed differences in production technology are enormous.

4.2.2 STRUCTURE OF THE MODEL

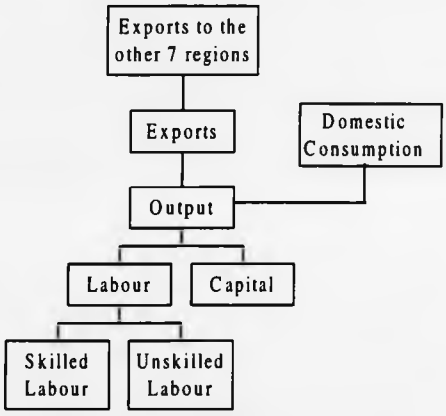
The structure of the model follows the standard specification of a multiregional general equilibrium model. I use the model constructed in Chapter 3, which is a static model consisting of eight regions, each one with demand and production structures. All regions are linked through trade. Each region contains three industries, each of which produces a single output, which are treated as heterogeneous across regions (Armington, 1969). There is a representative consumer in each region, and for simplicity, intermediate production is not considered.

On the production side of the model, two variants are considered. In the first variant, in each sector production involves a CES value added function with capital (K) and labour (L) as primary inputs; factor demands are obtained from cost minimisation. This is the same production structure previously used in Chapter 3 (see Figure 3.1).

The second variant of the model considers capital (K) and two types of labour: namely skilled labour and unskilled labour, denoted Ls and Lu respectively. In other words, the labour market is assumed to be segmented and this, as indicated

above, is a distinctive feature of this modelling exercise in comparison to previous work by Hamilton and Whalley (1984). This characteristic allows us to take into account distributional effects of migration among skilled labour, unskilled labour and capital owners. Figure 4.2 presents the production structure of the model when there is segmentation in the labour market.

Figure 4.2: Production structure in each sector



The model uses two-stage CES production functions, which are more flexible than non-nested functions, since they allow for different elasticity parameters in each stage of the production process. In the first stage, Ls and Lu are combined to produce the aggregate labour input (L); the labour aggregation function for industry i in region r, is given by,

$$L_i^r = \phi_i^r \left(\pi_i^r Ls_i^{r\left(\varsigma_i^r - 1\right)/\varsigma_i^r} + (1-\pi_i^r) Lu_i^{r\left(\varsigma_i^r - 1\right)/\varsigma_i^r} \right)^{\varsigma_i^r/\left(\varsigma_i^r - 1\right)}, \; i = 1,2,3; \; r = 1, \ldots,8, \qquad [1]$$

where L_i^r is the aggregate labour input; Ls_i^r and Lu_i^r are skilled and unskilled labour inputs; ϕ_i^r is a constant defining units of measurement; π_i^r is a share parameter;

and ς_i^r is the elasticity of substitution between skilled and unskilled labour in the production of the aggregate labour input.

Labour demand functions are obtained from cost minimisation; that is, each industry in each region selects an optimal level of Ls and Lu that minimises the cost of producing L units of the aggregate input. Aggregate supplies of skilled and unskilled labour are fixed.

In the second stage the aggregate labour input and capital are combined to produce value added. In each region each industry selects an optimal level of inputs that minimises the cost of producing value added. At this point, the structure of the model becomes the same as that of the model used in Chapter 3. The notation and equations are presented in Appendix 3.1.

Factors are non-produced commodities in fixed supply. It is assumed that factors of production are mobile across industries within each region, but are internationally immobile, although this assumption is relaxed later on for Ls.

The demand structure of the model is the same as that used in Chapter 3 (see Figure 3.2). The region's representative consumer demands composites of domestically produced and imported goods subject to the region's budget constraint (see Appendix 3.1).

As in Chapter 3, the model also incorporates income, factor and consumption taxes, as well as import tariffs, all of which are modelled in ad valorem form. All tax revenues raised are assumed to be transferred back to consumers. These policy instruments are not relevant to the issue being analysed; however, as they were included in the previous chapter, for convenience, it was decided to include them in order to avoid the adjustment of the benchmark data set.

Lastly, it is worth pointing out that some of the assumptions of the model may affect the outcome of the simulations. In global models it is usually assumed that capital is internationally immobile. This assumption may not be very realistic since international capital markets are becoming more integrated. However, this assumption is fundamental to the structure of the model; if all factors of production are allowed to move freely, the concept of region is no longer clear. Hence the need for a fixed factor in the specification of the model (in one of the extensions of the model, when capital is assumed to be internationally mobile, unskilled labour is the fixed factor in the model).[5]

Regarding labour, in the model it is assumed that differences in the marginal product of labour arise from barriers to inward mobility of labour in high-wage countries. Thus, once barriers to labour mobility are eliminated wage rates equalise across regions. The model also assumes that labour in one region is the same as labour in another region, so that differences in labour quality or human capital per worker across countries are ignored. In the real world these differences are not only present but may also be significant. For example, Lucas (1995) indicates that production per worker in the US is about fifteen times what it is in India; after correcting for differences in human capital, each American worker was estimated to be the equivalent of about five Indian workers. Another important factor that may affect labour productivity is the technology available in each region. Thus, the elimination of restrictions on labour mobility may not after all eliminate differences in productivity across regions. As can be seen, some of the assumptions used in the specification of the labour market may be highly simplified; however, incorporating

[5] Instead of having a fixed factor, a nontradable good could be introduced, so that all production factors could be inter-regionally mobile.

differences in the quality of labour across regions is severely constrained by data availability.

4.2.3 EQUILIBRIUM CONDITIONS IN THE MODEL

Once the model has been specified, it can be solved for an equilibrium solution. Equilibrium in the model is given by a set of goods and factor prices for which all markets clear. It is assumed that all factors are intersectorally mobile within each region; this means that there is only one price for each factor in each region. As to international factor mobility, it is initially assumed that all factors are internationally immobile, so that there are separate labour and capital equilibrium conditions in each region. That is, the region's endowment of capital and labour must equal factor use across all sectors (i.e. full employment occurs in all regions).

In the first variant of the model, in which the labour market is not segmented, the equilibrium conditions (i.e. demand-supply equalities, zero profit conditions and external-sector balance) are the same as in Chapter 3 (see Appendix 3.1). Assuming that the labour market is segmented requires the inclusion of an additional market clearing condition, which states that the supply of the aggregate labour input generated by the combination of Lu and Ls in each industry, must equal the demand for the aggregate labour input used in the production of value added in each industry. Further, it is necessary to introduce an additional zero profit condition, which states that the value of the aggregate labour input in each industry must be equal to the skilled and unskilled labour costs of producing the aggregate input in each industry.

Once the equilibrium conditions that characterise the model have been specified, counterfactual equilibria can be compared with the benchmark equilibrium

generated by the data. However, before doing this, the parameters of the model that are consistent with the benchmark data set are calculated. These parameters allow us to reproduce the data set as an equilibrium solution of the model.

4.3 EMPIRICAL IMPLEMENTATION

The model used to analyse the efficiency gains from the elimination of restrictions on labour mobility consists of eight regions: four developed regions (USA, JAP, EU, and ODC) and four developing regions (DAM, DAF, DAS, and DE). These regions were chosen to reflect world trade, and the 1990 data set assembled in the previous chapter was used. The disaggregation between developed and developing regions is important since individuals have incentives to migrate from regions with low wage rates (developing regions) to regions with higher wage rates (developed regions). The additional disaggregation into developed and developing regions is again of particular interest, since it provides an indication of the main source and destination regions (Table 3.1 in the previous chapter presents the grouping of individual countries).

As indicated above, each region produces three commodities, and each region's domestically produced and imported goods are qualitatively different (Armington, 1969). The price of the composite primary commodities demanded by the consumer in USA is chosen as the numeraire.

4.3.1 BENCHMARK DATA SET

The benchmark data set involves domestic and external sector data for each region. Domestic activity data involve data on value added by component by industry, the

segmentation of the labour market as well as domestic taxes. External sector data includes data on foreign trade and import tariffs. The size of the eight regions remains unaltered, and is given by their respective GDP in 1990 US dollars, consistent with the World Tables (World Bank, 1995) (see Appendix 3.2 for a detailed presentation of the sources and how the data set was assembled).

One of the modifications introduced to the data set was the segmentation of the labour market. National Accounts Statistics (United Nations, 1996) provide information on the cost components of value added, that is compensation of employees, gross operating surplus and net indirect taxes. However, this source reports the remuneration of employees without distinguishing between different types of labour. Information from (various issues of) the Yearbook of Labour Statistics of the International Labour Office (ILO) was then used to calculate the percentage of skilled and unskilled workers within the economically active population for each sector in each region. Using the methodology described in Appendix 4.1, the following percentages (of the number of employees) were obtained:

Table 4.1: Percentage of skilled and unskilled workers by sector

Regions	Primary Commodities		Manufactured Goods		Services	
	Skilled labour	Unskilled labour	Skilled labour	Unskilled labour	Skilled labour	Unskilled labour
USA	10.8%	89.2%	24.1%	75.9%	32.2%	67.8%
JAP	0.8%	99.2%	10.5%	89.5%	20.2%	79.8%
EU	1.7%	98.3%	13.1%	86.9%	24.3%	75.7%
ODC	10.0%	90.0%	14.9%	85.1%	28.7%	71.3%
DAM	1.9%	98.1%	8.2%	91.8%	19.5%	80.5%
DAF	0.5%	99.5%	7.7%	92.3%	18.4%	81.6%
DAS	0.1%	99.9%	4.6%	95.4%	11.8%	88.2%
DE	0.9%	99.1%	7.8%	92.2%	19.9%	80.1%

Source: Author's calculations. See Appendix 4.1

As can be seen, these percentages indicate that skilled labour is more abundant in developed regions. The percentages reported above are important since they are used to split the wage bill in each industry, as taken from the National Accounts, into remuneration to skilled and unskilled labour in each region. Table 4.2 presents the resulting costs components of value added for each sector when the labour market is segmented.

Table 4.2: Value added at factor costs

(1990 US$ Billions)

	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Primary Commodities								
Skilled labour	6.6	0.1	1.0	4.1	1.0	0.0	0.1	1.3
Unskilled labour	54.2	18.9	59.3	37.3	34.2	8.5	64.8	141.7
Capital	136.0	53.3	147.9	111.8	100.7	120.1	354.1	102.0
Manufactured Goods								
Skilled labour	164.8	44.9	116.9	32.8	6.3	1.0	4.3	16.3
Unskilled labour	518.2	381.8	777.5	188.2	71.3	11.6	91.1	191.5
Capital	272.3	292.8	417.4	103.3	161.5	23.0	143.6	83.9
Services								
Skilled labour	828.3	235.9	525.6	260.7	54.4	9.2	44.2	93.0
Unskilled labour	1,741.4	930.0	1,635.9	646.2	224.8	40.7	330.0	373.5
Capital	1,344.4	777.0	1,708.2	395.4	410.6	96.6	381.5	315.6

Source: Author's calculations. See Appendix 4.1

Once the segmentation of the labour market has been included, the data set was completed by incorporating foreign trade and final demand data. The resulting data sets are consistent with those presented in Appendix 3.2. Then, some parameters such as share parameters and scale parameters, can be directly calculated from the equilibrium conditions of the model, following the procedure described in Mansur

and Whalley (1984). Before that, it is necessary to specify parameter valued for the elasticities of substitution and transformation that are not contained in the data set.

4.3.2 ELASTICITIES

The elasticities used in the model play a key role in the results. In this case, the key elasticities in the model are the skilled-unskilled labour substitution elasticity, as well as the elasticity of substitution between capital and the aggregate labour input. The degree of substitutability between skilled and unskilled labour determines the change in relative wages once a policy change is introduced. The model also includes other elasticities such as the elasticities controlling substitution between import types in forming import composites, and those controlling substitution between comparable domestic goods and aggregate imports. These trade elasticities determine the strength of the terms of trade effects associated with trade policies.

The majority of studies on labour-labour substitution use a disaggregation by occupation to separate the labour force; in particular, due to data constraints the disaggregation most widely used is between production and non-production workers. There does not seem to be consensus as to an approximate value for the labour-labour substitution elasticity, and this is reflected by the fact that there is a rather large range of variation in the elasticity estimates, from 0.14 to 7.5 (Hamermesh and Grant 1979).[6] The big differences in the elasticity estimates can be the result of major methodological differences, such as the choice of estimating a cost or a production function, the choice of functional forms, the choice of data (time-series versus cross-

[6]Hamermesh (1993), however, points out that the substitution relationship between production and non-production workers tells us little about the substitution between high- and low-skilled workers because "...there is a remarkably large overlap in the earnings of these two groups" (p. 65).

section), and the disaggregation of the labour force according to various criteria, among others. The estimate of the elasticity of substitution between non-production-production workers was chosen as a proxy for the elasticity of substitution between skilled and unskilled labour. A value of 0.9 was used in the central case, and this value is used across sectors for all regions, since estimates for each industry in region were not available. Sensitivity analysis is performed around the value chosen in the range 0.5 to 2.5.[7]

In the value added functions the key parameters are the CES elasticities of substitution between the aggregate labour input and capital.[8] In this case, I used the same elasticities of substitution used in Chapter 3 (see Table 3.3).

On the demand side of the model, three different types of elasticities are involved with the CES forms used: elasticities of substitution in consumption between composite goods, those controlling substitution between import types in forming import composites, and those controlling substitution between comparable domestic goods and aggregate imports. The elasticities used in the model (central case) are the same as in Chapter 3 (see Table 3.3).

4.3.3 CALIBRATION

Once the data set has been assembled, and elasticity parameters have been specified, share and scale parameters can be calculated from the equilibrium conditions of the model, following the procedure described in Mansur and Whalley (1984).

---

[7] I also tried using elasticity values greater than 2.5, but I encountered numerical problems when solving the model.

[8] Whalley (1985) points out that there is no consensus as to the quantitative orders of magnitude involved, since most time-series estimates of the aggregate substitution elasticity are in the neighbourhood of unity, and cross-section estimates are often around 0.5.

The benchmark data set provides information on equilibrium transactions in value terms. The first step of the calibration procedure involves the separation of these transactions into price and quantity observations. In order to do this, a units convention is widely used, in which it is assumed that a physical unit of each good and factor is the amount that sells for one dollar. That is, both goods and factors have a price of unity in the benchmark equilibrium.

However, this approach is not applicable in the case of the labour market, because there are different marginal products of labour that are assumed to arise from barriers to inward mobility of labour in high-wage countries (that is, wages are different from one). In addition, there are two types of labour in the model, skilled and unskilled, each one with a different productivity and, as a result, a different price within each region. Hence, wage rates for each type of labour in each region must be calculated.

Six possible measures of average wage rates were calculated in order to assess the robustness of the results to the selection of the wage measure. The first measure, denoted WB/TOTP, takes the wage bill for each region (WB), as taken from National Accounts, and divides it by total population (TOTP), as taken from the UN Demographic Yearbook. Total population, however, exceeds the workforce in each region. Therefore, a second measure of the average wage rate, denoted WB/EAP, divides the wage bill by the economically active population (EAP).[9] The third and fourth measures, denoted GDPpc(TOTP) and GDPpc(EAP), use GDP per capita using TOTP and EAP, respectively. The fifth and sixth measures, denoted

[9] ILO (1996; p.5) defines the economically active population as "...all persons of either sex who furnish the supply of labour for the production of goods and services during a specified time-reference period".

AGDPpc(TOTP) and AGDPpc(EAP), use GDP per capita using TOTP and EAP, where the GDP has been adjusted by the exchange rate deviation index, that corrects for the difference between the official and the purchasing power parity exchange rates (Kravis et al., 1982).

Of these six measures, I consider that WB / EAP is best since the denominator involves all the labour force involved in the production process. With the use of TOTP the average wage rate is being underestimated since it includes population that do not participate in the production process such as children and elderly people. The wage measures based on GDP per capita were included for comparison purposes, since Hamilton and Whalley (1984) used this measure in their calculations. However, GDP per capita in only an approximate measure of average wages as it is a measure of economic activity, and not a measure of income. Furthermore, in the production of domestic output labour is not the only factor of production involved; physical capital and human capital are also involved. From GDPpc it is not possible to isolate the labour component.

Table 4.3 reports the relative wage rates calculated using the six measures mentioned above; wage rates are calculated relative to DAF wages, the region with the lowest wage rates in four out of the six measures used. Regardless of how the wage rates are calculated, USA, JAP, EU and ODC have higher wage rates than the developing world (i.e. DAM, DAF, DAS and DE).

Table 4.3: Relative wage rates – Homogeneous labour
(1990 US$)

Wage Measures	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB/TOTP	100.0	98.4	68.3	72.8	7.0	1.0	1.5	13.2
WB/EAP	75.1	78.2	60.0	61.4	7.4	1.0	1.5	10.8
GDP_{pc}(TOTP)	34.9	52.1	27.0	25.3	4.3	1.0	0.9	4.9
GDP_{pc}(EAP)	26.2	38.6	23.7	21.4	4.6	1.0	0.9	4.0
$AGDP_{pc}$(TOTP)	17.5	28.7	13.4	12.5	4.1	1.0	1.2	3.7
$AGDP_{pc}$(EAP)	13.1	21.2	11.8	10.6	4.4	1.0	1.2	3.0

Source: See Appendix 4.2

In the case where the labour market is segmented, it is necessary to calculate the average wage rates of skilled and unskilled labour in each region. Given that in practice such data are not available, average earnings per worker in finance, insurance, real state and business services were used as a proxy for skilled labour wages, while average earnings per worker in wholesale and retail trade, restaurants and hotels were used as a proxy for unskilled labour wages. The ratio between high and low wages is then used to infer the average wage rates for skilled and unskilled labour in each region (Appendix 4.2 presents how the average wage rates were calculated). The resulting relative wage rates for the two types of labour are reported in Table 4.4. Wage rates are calculated relative to unskilled DAF wages. Once again, regardless of the measure of wages used developed regions have higher wage rates than developing regions, for both types of labour.

Table 4.4: Relative wage rates – Heterogeneous labour

(1990 US$)

Wage Measures	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB/TOTP								
Unskilled labour	91.3	96.3	60.2	72.9	6.7	1.0	1.5	13.8
Skilled labour	150.0	158.1	122.2	97.6	13.1	1.8	2.2	17.3
WB/EAP								
Unskilled labour	68.5	71.3	52.9	61.6	7.1	1.0	1.6	11.3
Skilled labour	112.6	117.0	107.5	82.4	13.8	1.8	2.3	14.1
GDP_{pc}(TOTP)								
Unskilled labour	31.9	51.0	23.8	25.4	4.2	1.0	0.9	5.1
Skilled labour	52.4	83.7	48.3	33.9	8.1	1.8	1.3	6.4
GDP_{pc}(EAP)								
Unskilled labour	23.9	37.7	20.9	21.4	4.4	1.0	1.0	4.2
Skilled labour	39.3	62.0	42.5	28.6	8.6	1.8	1.4	5.2
$AGDP_{pc}$(TOTP)								
Unskilled labour	16.0	28.1	11.8	12.6	4.0	1.0	1.2	3.8
Skilled labour	26.2	46.1	23.9	16.8	7.7	1.8	1.8	4.8
$AGDP_{pc}$(EAP)								
Unskilled labour	12.0	20.8	10.4	10.6	4.2	1.0	1.3	3.1
Skilled labour	19.7	34.1	21.1	14.2	8.2	1.8	1.8	3.9

Source: See Appendix 4.2

Since the late 1970s there has been a widespread trend towards increasing skill premiums in developed countries. The increase in wage premiums was larger in the United States than in other developed countries; there were also large increases in the United Kingdom. In the United States, wage differential between college

graduates and high school graduates rose from 38% in 1980 to 53% in 1990, whereas the wage differential between college graduates and high school dropouts rose from 66% to 86% (Buckberg and Thomas, 1996; similar findings are reported by Murphy and Welch, 1992).

Several studies have tried to establish the cause of increasing wage differentials in developed countries. Some authors attribute this to increased immigration and the expansion of trade with developing countries (van de Klundert and Nahuis, 1998; Wood, 1995), whereas others argue that the effect of trade on wage inequality has been small (Lawrence and Slaughter, 1993). Borjas et al (1997) point out that there are other factors contributing to the increase in the skill premium, such as the acceleration of skill-biased technological change, the slowdown in the growth of the relative supply of college graduates, as well as institutional changes in the labour market. In addition, Kosters (1994) and Davis (1992) mention that government policies and practices such as deregulation (specially in the U.S), privatisation (specially in the U.K), wage-setting institutions (for example in France, the Netherlands and Sweden) could have powerful influences on relative wages. Buckberg and Thomas (1996) state that rising wage dispersion in the U.S., measured in terms of the education premium, can be explained by declines in manufacturing employment, loss of union power, and the impact of technology.

In the case of developing countries, Pissarides (1997) and Wood (1997) point out that both the return to labour and the skill premium have increased after trade liberalisation despite the low skill content of their exports. Pissarides (1997) also points out that in the cases of Colombia and Mexico, for example, wage inequality increased after trade liberalisation, and the most likely cause was the importation of skilled-biased technology from abroad.

The final step in the calibration procedure involves the use of price-quantity data to calculate parameters for demand and production functions from the benchmark equilibrium observations, given the required values of pre-specified parameters such as elasticities and tax rates. In order to do this, the equilibrium conditions together with first-order conditions (from utility maximisation and cost minimisation) are used to solve for function parameter values using equilibrium prices and quantities. Calibration allows us to test the solution procedure, and ensures the consistency of agents' behaviour with the benchmark data set. The model was solved using a routine I wrote in the General Algebraic Modelling System (GAMS) software.

4.4 Model results

The model presented above was used to calculate the world-wide efficiency gains from free mobility of labour (the results are presented for the six measures of wages mentioned before). Two scenarios are considered: in the first one labour is a homogeneous factor of production, while in the second one labour is classified as skilled and unskilled. In the latter scenario, two cases are considered: a) both skilled and unskilled labour migrate; and b) skilled labour is the only factor that migrates. The case where unskilled labour is the only factor that migrates was not considered since this is not a realistic case, given the actual international restrictions on labour mobility. The model does not consider illegal migration.

The removal of restrictions on labour mobility modifies the market clearing condition that determines the equilibrium wage rate. In particular, when labour is homogeneous the equilibrium condition is given by

$$\sum_{i=1}^{3}\sum_{r=1}^{8} L_i^r = \sum_{r=1}^{8} \overline{L_r}, \qquad [2]$$

where $\overline{L_r}$ corresponds to the region's endowment of labour. In the heterogeneous case the equilibrium condition is given by

$$\sum_{i=1}^{3}\sum_{r=1}^{8} Ls_i^r = \sum_{r=1}^{8} \overline{Ls_r}, \qquad [3]$$

where $\overline{Ls_r}$ corresponds to the region's endowment of skilled labour.

In the model international capital transfers are not considered, since it is assumed that migrant workers do not bring capital with them nor send capital back home. Capital flows and transfers may alleviate the negative effects of migration on wages. In addition, the model assumes that all migrant labour enter the labour market (some migrants such as children and elderly people will not actually work).

Once immigration controls are removed, labour migrates from low-wage to high-wage regions. The source regions are DAM, DAF, DAS, and DE, while the destination regions are USA, JAP, EU, and ODC. However, when the average wage rate is measured as WB/TOTP, DE becomes a destination region for the homogeneous labour case. When labour is heterogeneous, and both skilled and unskilled labour migrate, DE becomes a destination region for unskilled labour, and a source region for skilled labour when the average wage rate is measured as WB/EAP, WB/TOTP, and GDPpc(TOTP). Regardless of whether labour is homogeneous or heterogeneous, the amount of the factor entering DE is not considerable.

Table 4.5 quantifies the effects of the removal of immigration controls on welfare, as measured by the aggregate equivalent variation.[10] In the homogeneous

[10] The equivalent variation (EV) is a measure of welfare change. It is defined as the amount of money a particular change, that has taken place between equilibria, is equivalent to. In this case, an arithmetic sum of EVs, summed across regions is used.

labour case, there is a reduction in production in all sectors in the source regions. This is accompanied by a reduction in exports and an increase in imports which compensate for the reduction in domestic output. Conversely, in the destination regions, there is an increase in production in all sectors accompanied by an increase in exports and a reduction in imports from developing regions. In this case, there are large gains from the removal of global immigration controls, ranging from 14% to 62% of world GDP, which means that the results are quite sensitive to the measure chosen, but in any case the efficiency gains are considerable. These gains are not as large as those obtained by Hamilton and Whalley (1984), where in some cases the gains exceeded the world-wide economy GNP. The differences may be the result of the modelling frameworks (i.e. partial equilibrium versus general equilibrium), the flows of labour leaving low-wage regions, or units of measurement as Hamilton and Whalley (1984) use population, whereas in this case units of labour are used.

Table 4.5: Welfare effects of the removal of immigration controls
(Equivalent variation as a percentage of world GDP)

Wage measures:	Homogeneous Labour	Heterogeneous Labour	
		Both skilled and unskilled labour migrate	Only skilled labour migrates
WB/TOTP	62	55	11
WB/EAP	49	44	9
GDPpc (TOTP)	41	37	8
GDPpc(EAP)	32	29	6
AGDPpc(TOTP)	17	16	4
AGDPpc (EAP)	14	12	3

Table 4.5 also presents the welfare effects of the removal of immigration controls when labour is a heterogeneous factor. In this case, as in the previous

scenario with homogeneous labour, there is an increase in domestic output in developed regions, whereas output in all sectors reduces in developing countries; the reduction in domestic output is compensated by a reduction in all exports and an increase in imports from developed regions. When both skilled and unskilled labour migrate, efficiency gains range from 12% to 55% of world GDP. The gains are smaller than in the homogeneous case as a result of the technological constraint imposed by the substitutability between skilled and unskilled labour. Thus, with a segmented labour market skilled and unskilled labour have less opportunity to reallocate. When only skilled labour migrates, world-wide welfare gains are much smaller than in the previous two cases (from 3% to 11% of world GDP) because skilled labour represents a small fraction of the labour force in the source regions (i.e. 14% in DAM, 10% in DAF, 5% in DAS, and 14% in DE).

If regions are considered individually, estimates of the efficiency gains from the elimination of global restrictions on labour mobility show that all regions benefit in the three scenarios (see Table 4.6). The regions experimenting more emigration, that is DAF and DAS, obtain the largest welfare gains among the source regions. For instance, in the homogeneous labour case, when wages are measured as WB/EAP, these amount to 61% and 94% of GDP, respectively. Regarding the destination regions, those receiving more immigrants obtain the largest welfare gains. For example, in the homogeneous labour case, when wages are measured as WB/EAP, USA and JAP obtain welfare gains of 48% and 58% of GDP, respectively. In the heterogeneous labour case the results follow the same pattern with smaller, although still considerable, welfare gains.

Table 4.6: Welfare effects of the removal of immigration controls by region (Equivalent variation as a percentage of regional GDP)

Wage Measures	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Homogeneous Labour								
WB/TOTP	66	79	60	60	15	64	105	9
WB/EAP	48	58	52	49	12	61	94	7
GDP_{pc}(TOTP)	36	70	37	33	10	40	87	4
GDP_{pc}(EAP)	25	51	32	26	8	37	77	4
$AGDP_{pc}$(TOTP)	12	32	14	11	6	28	52	2
$AGDP_{pc}$(EAP)	8	22	12	9	4	25	44	1
Heterogeneous labour - Both skilled and unskilled labour migrate								
WB/TOTP	55	74	53	52	14	63	100	10
WB/EAP	40	54	45	43	12	59	88	8
GDP_{pc}(TOTP)	30	66	32	29	10	38	82	6
GDP_{pc}(EAP)	21	48	28	24	8	35	72	5
$AGDP_{pc}$(TOTP)	10	30	12	10	5	26	49	2
$AGDP_{pc}$(EAP)	7	21	10	8	4	23	41	1
Heterogeneous labour – Only skilled labour migrates								
WB/TOTP	11	10	10	8	4	26	31	1
WB/EAP	8	8	9	6	4	25	28	1
GDP_{pc}(TOTP)	6	10	7	4	3	14	27	1
GDP_{pc}(EAP)	4	8	6	3	2	12	24	1
$AGDP_{pc}$(TOTP)	2	6	3	2	2	10	15	1
$AGDP_{pc}$(EAP)	1	4	3	1	1	8	13	1

The segmentation of the labour market also allows us to examine the distributional effects of immigration between skilled and unskilled labour in each

region. Tables 4.7 to 4.9 present the distributional impacts of the removal of immigration controls for the six measures of wages considered. A priori one would expect that labour migration from the source regions increases the labour supply in the destination regions, reducing the average wage rate (assuming no rigidities), and benefiting capital owners. In the source regions, the removal of immigration controls is expected to reduce the labour supply, increasing the average wage rate. As a result, capital is less scarce relative to labour, so that a reduction in the return to capital is expected.

In the case of homogeneous labour, capital owners in the destination regions benefit from migration through higher rental rates, whereas in the source regions workers benefit as a result of migration and capital owners lose (see Table 4.7). In the source regions, both wage rates and the return to capital increase, but the former increases even more.

Table 4.7: Distributional effects of the removal of immigration controls in the model with homogeneous labour (% change in factor prices)

	Regions							
Wage measures:	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP								
Wage rate	-61	-61	-43	-47	454	3,768	2,565	194
Return to capital	88	94	77	105	316	962	871	210
WB / EAP								
Wage rate	-53	-52	-41	-43	376	3,419	2,237	226
Return to capital	74	80	66	91	268	871	777	224
GDP pc (TOTP)								
Wage rate	-46	-64	-30	-25	336	1,796	2,052	289
Return to capital	63	65	59	85	242	495	709	258
GDP pc (EAP)								
Wage rate	-37	-57	-30	-23	259	1,552	1,716	262
Return to capital	50	48	45	69	192	424	604	230
AGDP pc (TOTP)								
Wage rate	-28	-56	-5	1	206	1,167	985	246
Return to capital	23	11	38	49	150	319	372	209
AGDP pc (EAP)								
Wage rate	-21	-51	-12	-2	136	935	758	247
Return to capital	17	0	24	36	104	253	291	200

Let us now consider the case of heterogeneous labour (see Tables 4.8 and 4.9). When both skilled and unskilled labour migrate, average wages increase in the source regions because labour is less abundant relative to capital, and the return to capital decreases relative to wages. The removal of immigration controls benefits

skilled labour more than unskilled labour, because the former is a small proportion of the total labour force, and after migration this factor is more scarce in developing regions. In the destination regions average wages reduce for both skilled and unskilled labour, since labour is now less scarce relative to capital, and the return to capital increases.

When only skilled labour migrates, there is a substantial increase in the remuneration of this type of labour in the source regions, since this factor of production is not abundant in these regions. Unskilled workers and capital owners are worse off relative to skilled labour as a result of migration, despite the fact that there is an increase in their remuneration. As to the destination regions, the inflow of skilled labour increase the supply of this type of labour, hence reducing its average wage rate. As expected, the average wage of unskilled labour and the return to capital increase. Skilled labour is worse off. The flexibility of wages allows the labour market to absorb labour immigration. Lower wages induce an increase in labour demand and in aggregate employment.

Table 4.8: Distributional effects of the removal of immigration controls in the model with heterogeneous labour - Both skilled and unskilled labour migrate (% change in factor prices)

	Regions							
Wage measures:	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP								
Wage rate skilled labour	-43	-46	-30	-12	555	4,629	3,774	395
Wage rate unskilled labour	-61	-63	-41	-51	430	3,435	2,200	157
Return to capital	81	84	72	98	311	919	810	207
WB / EAP								
Wage rate skilled labour	-34	-37	-31	-10	436	3,985	3,141	425
Wage rate unskilled labour	-53	-55	-40	-48	353	3,097	1,911	184
Return to capital	67	69	59	83	259	820	713	216
GDP pc (TOTP)								
Wage rate skilled labour	-27	-55	-21	12	369	1,997	2,744	496
Wage rate unskilled labour	-46	-66	-28	-32	314	1,620	1,748	238
Return to capital	56	53	53	78	230	460	644	246
GDP pc (EAP)								
Wage rate skilled labour	-20	-49	-26	10	266	1,632	2,173	504
Wage rate unskilled labour	-38	-61	-29	-31	238	1,387	1,445	258
Return to capital	44	37	40	62	179	389	540	248
AGDP pc (TOTP)								
Wage rate skilled labour	-15	-52	-7	32	187	1,122	1,150	362
Wage rate unskilled labour	-28	-59	-3	-9	190	1,048	830	200
Return to capital	20	2	34	43	137	289	327	191
AGDP pc (EAP)								
Wage rate skilled labour	-11	-49	-17	24	114	866	856	348
Wage rate unskilled labour	-22	-55	-9	-11	125	840	636	201
Return to capital	14	-7	20	30	93	227	254	181

Table 4.9: Distributional effects of the removal of immigration controls in the model with heterogeneous labour – Only skilled labour migrates (% change in factor prices)

	Regions							
Wage measures	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP								
Wage rate skilled labour	-66	-68	-58	-48	291	2,724	2,214	195
Wage rate unskilled labour	5	31	28	20	83	179	155	94
Return to capital	4	29	24	21	83	158	157	95
WB / EAP								
Wage rate skilled labour	-58	-60	-56	-43	238	2,476	1,944	231
Wage rate unskilled labour	4	27	23	17	71	161	138	97
Return to capital	3	25	20	19	70	143	140	100
GDP pc (TOTP)								
Wage rate skilled labour	-52	-70	-48	-26	210	1,290	1,785	295
Wage rate unskilled labour	3	20	21	19	65	96	126	110
Return to capital	2	18	19	20	65	87	128	113
GDP pc (EAP)								
Wage rate skilled labour	-44	-64	-48	-23	157	1,118	1,498	324
Wage rate unskilled labour	2	15	16	16	52	82	107	110
Return to capital	2	13	14	17	51	74	108	115
AGDP pc (TOTP)								
Wage rate skilled labour	-33	-62	-26	5	127	870	892	267
Wage rate unskilled labour	-0	1	14	16	41	64	67	91
Return to capital	-1	-0	13	16	41	58	68	94
AGDP pc (EAP)								
Wage rate skilled labour	-25	-57	-30	3	79	709	701	275
Wage rate unskilled labour	-0	-3	8	12	28	50	52	86
Return to capital	-1	-4	7	12	28	45	53	90

The amount of labour leaving the source regions varies depending on the measure used to calculate average wages (see Table 4.10). For example, when these are measured as WB/TOTP, 49% of the labour endowment of developing regions migrate to developed regions; when the average wage rate is measured as AGDPpc(EAP), this percentage reduces to 36%. On the other hand, when both skilled and unskilled labour migrate in the heterogeneous labour case, the percentage of labour leaving the source regions varies from 34% (average wage rate measured as AGDPpc(EAP)) to 47% (average wage rate measured as WB/TOTP). When only skilled labour migrates, between 58% and 72% of the skilled labour endowment of developing regions migrate, depending on how the average wage rate is calculated.

Table 4.10: Migration flows
(as a percentage of developing regions' labour endowment)

Wage measures:	Homogeneous Labour	Heterogeneous Labour	
		Both skilled and unskilled labour migrate	Only skilled labour migrates*
WB / TOTP	49	47	72
WB / EAP	48	46	71
GDP pc (TOTP)	46	44	69
GDP pc (EAP)	44	42	67
AGDP pc (TOTP)	38	36	61
AGDP pc (EAP)	36	34	58

* Migration as a percentage of developing regions' skilled labour endowment.

In summary, migration leads to factor reallocation, and during this process there are winners and losers. In the source regions, labour becomes more scarce relative to capital (between 36% and 49% of the labour endowment of developing regions migrate to developed regions, depending on the wage measure used), and capital owners lose. However, not all workers are better off, since labour is a

heterogeneous factor. Emigration will benefit workers whose skills are substitute to those of migrant labour, whereas it will hurt those workers whose skills are complementary to those of migrant workers. On the other hand, in the destination regions, labour becomes more abundant (less scarce) relative to capital, so that capital owners benefit. However, not all workers are worse off, because labour is a heterogeneous factor. Immigration will benefit those workers whose skills are complementary to those of the immigrant worker, whereas immigration will hurt those workers whose skills are substitute to those of immigrant workers.

Finally, the removal of global restrictions on labour mobility leads to an improvement in global income distribution, as measured by the Gini coefficient.[11] In the benchmark case, the calculated coefficient was 0.41; once the restrictions to labour mobility were eliminated this coefficient reduced, suggesting a move toward equality. The coefficient varied from 0.30 to 0.37, depending on the measure of wages used.

4.4.1 SENSITIVITY ANALYSIS

Some of the elasticities used in the model play an important role in the results. In what follows sensitivity analysis is performed on the key elasticities of the model. First, the elasticity of labour-labour substitution was varied from 0.5 to2.5. This is a very important elasticity in the model since the model has a segmented labour market, and the degree of substitutability between skilled and unskilled labour determines the change in relative wages once a policy change is introduced.

[11] The Gini coefficient is the most commonly used measure of income distribution. As is well known, this coefficient has a maximum value of one (absolute inequality), and a minimum of zero (absolute equality); see e.g. Sen (1997).

Assuming that both skilled and unskilled labour migrate, the welfare gains from the removal of immigration controls change little with respect to the initial specification (see Table 4.11). When only skilled labour migrates, welfare gains increase with the elasticity and in some cases considerably; in fact, the efficiency gains more than double as the labour-labour substitution elasticity increases from 0.5 to 2.5. Regarding the distributional impact (see Appendix 4.3), as the elasticity increases the average wage of skilled labour reduces more in the destination regions, and increases less in the source regions. The remuneration of unskilled labour increases more in the source regions, and reduces less in the destination regions.

Table 4.11: Sensitivity analysis – Welfare effects of the removal of immigration controls: Heterogeneous labour
(Equivalent variation as a percentage of world GDP)

	Labour-labour substitution elasticities in all regions					
Wage measures:	0.50	0.75	1.00	1.50	1.75	2.50
Both skilled and unskilled labour migrate:						
WB / TOTP	54	54	55	55	56	56
WB / EAP	43	44	44	44	44	45
GDP pc (TOTP)	36	37	37	37	37	38
GDP pc (EAP)	29	29	29	30	30	30
AGDP pc (TOTP)	16	16	16	16	16	16
AGDP pc (EAP)	12	12	12	12	12	12
Only skilled labour migrates:						
WB / TOTP	7	10	12	14	14	16
WB / EAP	6	8	10	11	12	13
GDP pc (TOTP)	5	7	8	10	10	11
GDP pc (EAP)	5	6	7	8	9	9
AGDP pc (TOTP)	3	3	4	5	5	6
AGDP pc (EAP)	2	3	3	4	4	5

Second, the elasticities of substitution in the production of value added were set at values between 0.5 and 1.5 in all regions. In the homogeneous case, this substitution elasticity corresponds to the elasticity of substitution between capital and labour; in the heterogeneous labour case, this elasticity corresponds to the elasticity of substitution between the aggregate labour input and capital.

Table 4.12 presents the welfare effects of the removal of immigration controls when the elasticities of substitution in production in all regions are varied at values between 0.5 and 1.5. In general terms, the removal of immigration controls produces considerable welfare gains, and these tend to be greater the larger the elasticity of substitution. For example, in the initial specification, when the average wage rate was calculated as WB/EAP and labour was homogeneous, the efficiency gains amount to 49% of world GDP; when the elasticity of substitution is increased 1.5, efficiency gains increase to 54% of world GDP. The distributional impacts of the removal of immigration controls are also similar to those described for the initial specification (see Appendix 4.4). For example, with heterogeneous labour and lower values of the elasticity of substitution, the losses of skilled workers in the destination regions are bigger, and the gains of skilled workers in the source regions are smaller. The wage rates of unskilled labour increase less in destination regions, and more in source regions.

Table 4.12: Sensitivity analysis -Welfare effects of the removal of immigration controls (Equivalent variation as a percentage of world GDP)

	Elasticities of substitution in production in all regions				
	0.50	0.75	1.00	1.25	1.50
Homogeneous labour					
WB / TOTP	49	57	62	65	68
WB / EAP	40	46	50	52	54
GDP pc (TOTP)	33	39	42	44	45
GDP pc (EAP)	27	31	33	34	36
AGDP pc (TOTP)	15	16	18	19	19
AGDP pc (EAP)	11	13	14	14	15
Heterogeneous labour Both Ls and Lu migrate					
WB / TOTP	44	51	55	58	60
WB / EAP	36	41	44	46	48
GDP pc (TOTP)	30	35	37	39	41
GDP pc (EAP)	24	28	30	31	32
AGDP pc (TOTP)	13	15	16	17	17
AGDP pc (EAP)	10	12	12	13	13
Heterogeneous labour Only Ls migrates					
WB / TOTP	10	11	11	11	11
WB / EAP	9	9	9	9	9
GDP pc (TOTP)	7	8	8	8	8
GDP pc (EAP)	6	6	6	7	7
AGDP pc (TOTP)	4	4	4	4	4
AGDP pc (EAP)	3	3	3	3	3

In general, the main predictions of the model remain unaltered, in the sense that the elimination of immigration controls generates world-wide efficiency gains. In addition, in the destination regions capital owners benefit from labour immigration, and workers lose because of lower wages; in the source regions, capital owners are worse off relative to labour and workers benefit. When the labour market is segmented, the sensitivity analysis also confirms that migration of skilled labour hurts unskilled labour in the source regions.

4.5 MODEL EXTENSIONS

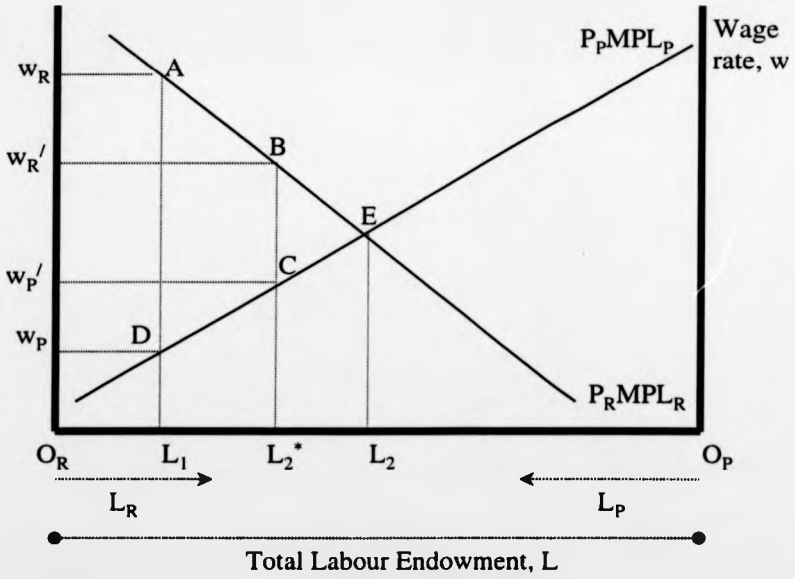
In this section three new features are introduced to the model: a) transaction costs; b) international capital mobility; and c) selective labour mobility. For brevity I shall only focus on the results of two out of the six measures of average wages considered: WB/TOTP, and AGDPpc(EAP). These two measures were chosen as they provided the extreme results.

4.5.1 TRANSACTION COSTS

The first elaboration of the model is the introduction of transaction costs. This extension of the model seems appropriate, since migration is a costly process. There are costs involved in the process of moving from one region to another, such as transport costs, the costs of settling in other region, the costs of finding a new job, and the costs of leaving friends and family behind. With the elimination of restrictions to labour mobility, labour will move until the marginal product of labour equals the cost of hiring labour. However, in the presence of transaction costs wages fail to equalise across regions, so that a single market clearing wage no longer

characterises the equilibrium. Transaction costs thus drive a wedge between wages in developed and developing countries. This can be illustrated in Figure 4.3, where the removal of barriers to labour mobility lowers the wage rate in the rich country from W_R to W_R' and increases the wage rate in the poor country from W_P to W_P'. Migration flows are now given by the distance $L_1 - L_2^*$, which is smaller when compared to the case without transaction costs ($L_1 - L_2$).

Figure 4.3: The effects of migration in the presence of transaction costs



In the literature on general equilibrium with transaction costs, the assumption of a fixed transactions technology is usually used (see e.g. Foley, 1970; Maechler and Roland-Holst, 1997).[12] In this model transaction costs were modelled as a tax (without revenue), whose rate is exogenously determined. The price received by

[12] Nguyen and Whalley (1986) present an equilibrium model for an exchange economy with fixed prices and endogenously determined transaction costs.

owners of labour in each region corresponds to a percentage of the market clearing price when restrictions to labour mobility are eliminated. That is, the price of labour in each region is given by

$$P_L^r = W(1 - TC^r), \qquad [4]$$

where W corresponds to the world price of labour, and TC^r corresponds to regional transaction costs.

Transaction costs are difficult to quantify since there are no measures available. As mentioned earlier, there are costs associated with migration from low-wage to high-wage regions. In the case of developing regions, these costs could be very high. Taking into account the substantial differences in relative wages among the regions, the following values for TC^r were assumed: 0.9 for DAF and DAS; 0.8 for DAM; and 0.7 for DE. The transaction costs for developed regions (USA, JAP, EU, and ODC) are assumed to be much smaller (i.e. 0.1), and reflect the fact that workers in these regions have little or no incentive to move to low-wage regions.

As can be seen from Table 4.13, the introduction of transaction costs reduces migration flows. For example, when the average wage is measure as WB/TOTP, and labour is homogeneous, migration reduces from 49% of the developing regions' endowment of labour to 35%. In the heterogeneous labour scenario, migration reduces from 47% of the developing regions' endowment of labour to 29% when the two types of labour are allowed to migrate, and from 72% of the developing regions' endowment of skilled labour to 65% when only skilled labour migrates.

Table 4.13: Migration flows in the presence of transaction costs
(Migration as a percentage of developing regions' labour endowment)

	Homogeneous Labour	Heterogeneous Labour	
		Both Ls and Lu Migrate	Only Ls Migrates*
Without transaction costs			
WB / TOTP	49	47	72
AGDP pc (EAP)	36	34	58
With transaction costs			
WB / TOTP	35	29	65
AGDP pc (EAP)	5	1	16

* Migration as a percentage of developing regions' skilled labour endowment.

The welfare gains as a result of the removal of immigration controls are smaller in the presence of transaction costs (see Table 4.14). Regarding the distributional effects, the main conclusions remain unaltered. That is, labour benefits (loses) relative to capital in the source (destination) regions. When the labour market is segmented, skilled labour benefits relative to unskilled labour in the source regions; in the destination regions the two types of labour lose, but unskilled workers are hurt even more when both skilled and unskilled labour migrate.

Table 4.14: Welfare effects of the removal of immigration controls in the presence of transaction costs
(Equivalent variation as a percentage of world GDP)

	Homogeneous Labour	Heterogeneous Labour	
		Both Ls and Lu Migrate	Only Ls migrates
Without transaction costs			
WB / TOTP	62	55	11
AGDP pc (EAP)	14	12	3
With transaction costs			
WB / TOTP	27	20	6
AGDP pc (EAP)	1	1	1

Finally, it is not surprising that migration and welfare gains increase as the transaction costs for the developing regions are reduced (these results are not reported here). This is the case since transaction costs distort the labour market, specially in developing regions, and as the distortion is reduced, efficiency increases and wage gap reduces.

4.5.2 CAPITAL MOBILITY

In the second elaboration of the model international capital mobility is introduced. Although this feature is usually ignored in global models (see e.g., Whalley, 1985; Shoven and Whalley, 1992), it seems interesting to include it in the model since capital markets are becoming more integrated internationally. In this case, the return to capital equalises across regions. Therefore, a single market clearing rental rate characterises the equilibrium; that is, the market clearing condition for the market of the capital factor is given by,

$$\sum_{i=1}^{3}\sum_{r=1}^{8} K_i^r = \sum_{r=1}^{8} \overline{K_r}, \qquad [5]$$

that is the sum of factor use across all industries and regions must equal the global endowment of the factor.

The simulations were carried out for the scenario in which labour is a heterogeneous factor and only skilled labour migrates, since a fixed factor (in this case unskilled labour) is needed. If all factors of production are allowed to move freely, the concept of region is no longer clear.

When restrictions to skilled labour mobility are removed, labour moves from regions with low wages (DAM, DAF, DAS, and DE) to regions with high wages (USA, JAP, EU, and ODC). Capital moves from regions where it is abundant relative to labour (USA, JAP, EU, and ODC) to regions where it is scarce relative to labour (DAM, DAF, DAS, and DE). The effects over the remuneration of the factors of production are similar to those obtained when capital is not internationally mobile. A substantial increase in the remuneration of skilled labour in the source regions is observed, since this factor is not abundant in these regions, whereas unskilled labour and capital owners are worse off. In the destination regions, the remuneration of skilled labour falls and unskilled labour and capital owners are better off (see Table 4.15). The effects of capital mobility on the return to capital are smaller than the effects of skilled labour mobility on wages. This is explained by the fact that capital flows from developed to developing regions are smaller than labour flows from developing to developed regions. In particular, when wages are measured as WB/TOTP, migration flows account for 54% of the world endowment of labour whereas capital flows account for only 8% of the world endowment of capital.

In addition, aggregate welfare improves compared with the scenario without capital mobility (see Table 4.16). The improved welfare is the result of a better resource allocation with smaller distributional effects.

Table 4.15: Distributional impact of the removal of immigration controls in the presence of capital mobility
(% change in factor prices)

	Regions							
Wage measures	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP								
Wage rate skilled labour	-70	-72	-64	-55	238	2,343	1,901	156
Wage rate unskilled labour	0	11	10	5	30	78	72	36
Return to capital	18	18	18	18	18	18	18	18
AGDP pc (EAP)								
Wage rate skilled labour	-30	-59	-34	-2	70	664	656	254
Wage rate unskilled labour	-1	-0	3	5	10	22	24	39
Return to capital	7	7	7	7	7	7	7	7

Table 4.16: Welfare effects of the removal of immigration controls in the presence of capital mobility
(Equivalent variation as a percentage of world GDP)

Wage measures	Only Ls Migrates
Without capital mobility	
WB / TOTP	11
AGDP pc (EAP)	3
With capital mobility	
WB / TOTP	12
AGDP pc (EAP)	4

The previous results should be taken with caution since they are ruled by the specification of the capital market. That is, since a competitive market is assumed, capital will respond to variations in its rate of return. However, as indicated by

Layard et al (1992), developing regions have low productivity, and it is possible that migration from DAM, DAF, DAS, and DE to USA, JAP, EU, and ODC would divert capital to developed regions that could be instead invested in developing regions.[13]

4.5.3 SELECTIVE LABOUR MOBILITY

The third elaboration of the model is the introduction of selective labour mobility. This extension seems interesting since some countries have signed bilateral labour agreements with other countries that cover project-link work, seasonal work, work in border areas, and guest workers.[14] I focus on the case where individuals in some particular regions in the developing world are allowed to migrate to developed regions. The following seven possibilities are considered:

- Workers in DAM migrate to USA, JAP, EU, and ODC.
- Workers in DAF migrate to USA, JAP, EU, and ODC.
- Workers in DAS migrate to USA, JAP, EU, and ODC.
- Workers in DE migrate to USA, JAP, EU, and ODC.
- Workers in DAM migrate to USA.
- Workers in DAS migrate to JAP.
- Workers in DAF and DE migrate to EU.

Each of these seven possibilities is analysed when labour is homogeneous, when labour is heterogeneous and both skilled and unskilled workers migrate, and when labour is heterogeneous and only skilled workers migrate.

---

[13] Lucas (1995) provides an alternative explanation.

[14] For example, Germany have signed labour agreements with Hungary, Poland, and the Czech Republic. Also Belgium, France and Switzerland have signed labour agreements with East European countries (Weyerbrock, 1995).

Under this elaboration, the average wage equalises across the regions involved, whereas each of the excluded regions will have a market clearing condition for the labour market.

An aggregate welfare improvement is observed in all seven cases (see Table 4.17). The magnitude of the welfare gains depends on the size of the source region in terms of the labour endowment. In particular, the highest welfare gains are obtained when workers in DAS are allowed to migrate to USA, JAP, EU, and ODC, since DAS is the most densely populated region, and has one of the lowest average wages. Conversely, the lowest welfare gains are obtained when DE is allowed to migrate to USA, JAP, EU, and ODC; this result is not surprising since DE is the third region in terms of population in the developing world, and the region's average wages are, in some cases, the highest in the developing world.

Table 4.17: Welfare effects of the removal of immigration controls in the presence of selective labour mobility
(Equivalent variation as a percentage of world GDP)

Migration Scenarios	Homogeneous Labour	Heterogeneous Labour	
		Both Ls and Lu Migrate	Only Ls migrates
DAM → USA, JAP, EU, ODC			
• WB / TOTP	5	11	3
• AGDP pc (EAP)	2	2	1
DAF → USA, JAP, EU, ODC			
• WB / TOTP	12	36	5
• AGDP pc (EAP)	17	3	1
DAS → USA, JAP, EU, ODC			
• WB / TOTP	54	66	13
• AGDP pc (EAP)	13	12	4
DE → USA, JAP, EU, ODC			
• WB / TOTP	3	6	3
• AGDP pc (EAP)	4	3	3
DAM → USA			
• WB / TOTP	4	16	4
• AGDP pc (EAP)	2	1	1
DAS → JAP			
• WB / TOTP	25	37	4
• AGDP pc (EAP)	9	8	2
DAF, DE → EU			
• WB / TOTP	11	11	3
• AGDP pc (EAP)	4	3	1

Note: → indicates the direction of the migration flow.

In terms of the amount of labour that moves between regions, the largest movement occurs when workers in DAS are allowed to migrate to USA, JAP, EU, and ODC. In the homogeneous case, the proportion of labour that moves out of DAS varies between 15% and 34% of the world endowment of labour; in the heterogeneous labour case, the proportion of labour that moves out of DAS varies between 12% and 34% of the world endowment of labour. Conversely, the smallest amount of migration occurs when the work force in DE is allowed to migrate to USA, JAP, EU, and ODC. These results suggest a positive relationship between the amount of migration and welfare gains.

As to the distributional impact of the removal of immigration controls (see Appendix 4.5), the introduction of selective labour mobility does not affect the main conclusions in the homogeneous labour case, that is workers in the source regions and capital owners in the destination regions benefit from migration. However, the magnitude of the distributional effects tends to be smaller in the destination regions, and larger in the source regions.

Let us now consider the heterogeneous labour case with skilled and unskilled labour migration. To begin with, when workers in DAM migrate to USA, JAP, EU, and ODC, skilled labour in ODC also migrates to the other developed regions because the remuneration of this factor is the lowest of the developed world.[15] Skilled and unskilled labour are better off relative to capital in the source regions, and in DAM unskilled labour is better off relative to skilled labour. This result contrasts with the findings in the central case, and can be explained by the fact that more unskilled labour is migrating out of the region. In the other selective labour

[15]ODC also becomes a source of skilled labour when only workers in DAF, and only workers in DE are allowed to migrate to the developed world.

mobility cases, skilled labour is better off relative to unskilled labour and capital in the source regions, whereas in the destination regions unskilled labour is worse off relative to skilled labour, and capitalists benefit.

Lastly, when there is a segmented labour market and skilled labour migrates, skilled workers gain in the source regions relative to unskilled workers; in the destination regions, both unskilled and skilled labour lose relative to capital, although unskilled labour loses less than skilled labour.

4.6 CONCLUDING REMARKS

In this chapter I have computed world-wide efficiency gains from the elimination of global restrictions on labour mobility. A general equilibrium model was used, since this is an ideal framework to analyse the effects of policy changes on resource allocation, the structure of distribution, and thus in economic welfare. Further, the general equilibrium framework takes account of the linkages among the eight regions, because in these models regions are not only linked though trade but also through labour flows (and capital flows in one of the extensions of the model).

One of the key features of the model is the introduction of a segmented labour market, as two types of labour are considered, namely skilled and unskilled. When labour is heterogeneous, two cases are considered: both skilled and unskilled labour migrate, and only skilled labour migrates. In the analysis, wages differ across regions because of the existence of barriers to labour mobility, and wage rates are equalised as a result of the elimination of restrictions to labour mobility rather than free trade.

The results of the model indicate that the elimination of global restrictions on labour mobility generates world-wide efficiency gains of considerable magnitude,

ranging from 14% to 62% of world GDP. When only skilled labour is allowed to migrate welfare gains are smaller, since skilled labour is a small proportion of the labour force in developing regions; in this case, efficiency gains range from 3% to 11% of world GDP.

The removal of global restrictions on labour mobility also leads to an improvement in global income distribution, as measured by the Gini coefficient. With the removal of immigration controls the resulting Gini coefficient varied between 0.30 and 0.37 (depending on the wage measure used), which compared with the coefficient in the benchmark case (i.e. 0.41) suggests a move towards equality.

Migration also leads to a process of factor reallocation in which there are winners and losers. In the source regions, labour becomes more scarce relative to capital, and capital owners lose relative to labour. However, not all workers are better off since labour is a heterogeneous factor. Emigration will benefit workers whose skills are substitute to those of migrant labour, whereas it will hurt those workers whose skills are complementary to those of migrant workers. On the other hand, in the destination regions, labour becomes more abundant (less scarce) relative to capital, and capital owners benefit. Again, not all workers in the destination regions are worse off. Immigration will benefit those workers whose skills are complementary to those of the immigrant worker, whereas immigration will hurt those workers whose skills are substitute to those of immigrant workers.

In a subsequent stage of the analysis, three model extensions were considered: a) transportation costs; b) capital mobility; and c) selective labour mobility.

With the introduction of transaction costs, wages fail to equalise across regions, migration flows reduce and in consequence efficiency gains reduce as well. With the introduction of capital mobility, the return to capital equalises across

regions; the removal of restrictions to skilled labour mobility makes labour move out of the regions with low average wages, and capital moves out of the regions where it is abundant relative to labour. Global welfare improves compared with the scenario without capital mobility, as a result of a better resource allocation and migrants benefit as well. With the introduction of selective labour mobility, an aggregate welfare improvement is observed, and the magnitude of the gain depends on the size of the region in terms of the labour endowment. As to the remuneration to the factors of production, the main conclusions remain unaltered: labour benefits in the source regions, and capital in the destination regions. With a segmented labour market, skill labour benefits from migration relative to unskilled labour in the source regions.

The results have shown that the elimination of global restrictions on labour mobility generates considerable world-wide efficiency gains. Despite these gains, the liberalisation of world-wide migration is far from realistic because of social and political tensions. High-income countries are very reluctant to open their borders to free migration because they do not want to become the destination of immigration of unskilled labour from low-income countries. In the short-run, countries regulate the flows of international migration by means of border controls, and work permits, among others. In the long-run, countries should concentrate their efforts in the reduction of income disparities among regions, which could reduce the incentive to migrate.

Appendix 4.1: Methodology used to calculate the percentage of skilled and unskilled labour in each region

Various issues of the Yearbook of Labour Statistics of the International Labour Office (ILO) are used to calculate the proportions of skilled and unskilled labour in each region. Information for as many countries as possible, and as close as possible to 1990, the base year of the benchmark data set, was obtained. In particular, data for the following countries and years were used:

- USA: 1991.
- JAP: 1990.
- EU: Belgium, 1990; Denmark, 1990; Germany, 1991; Greece, 1990; Ireland, 1990; Italy, 1994; Luxembourg, 1991; the Netherlands, 1991; Portugal, 1990; Spain, 1991; and the United Kingdom, 1992.
- ODC: Australia, 1990; Austria, 1990; Canada, 1990; Finland, 1991; Iceland, 1991; Israel, 1990; New Zealand, 1991; Norway, 1990; South Africa, 1991; Sweden, 1991; and Switzerland, 1991.
- DAM: Chile, 1991; Costa Rica, 1990; Ecuador, 1990; Mexico, 1990; Peru, 1991; and Venezuela, 1990.
- DAF: Botswana, 1991; Egypt, 1990; Morocco, 1991; and Nigeria, 1986.
- DAS: Indonesia, 1990; Korea, 1991; the Philippines, 1990; and Thailand, 1980.
- DE: Hungary, 1990; Poland, 1988; Romania, 1992; and Turkey, 1990.

Table 2C of the Yearbook presents economically active population (EAP) by industry and by occupation (major groups). Industries are classified, according to the International Standard Industrial Classification (ISIC), in nine broad categories. Primary commodities correspond to the first two categories, that is agriculture,

hunting, forestry and fishing, and mining and quarrying. Manufactured goods include all the manufacturing sector. And services comprise the remaining six categories, that is electricity, gas and water; construction; wholesale and retail trade, restaurants and hotels; transport, storage and communications; finance, insurance, real state and business services; community, social and personal services; and government services.

Occupations are in turn classified according to the International Standard Classification of Occupations (ISCO – 1968). In particular, the major groups 0/1 and 2 were assumed to comprise "skilled" workers; these groups include professional, technical and related workers, and administrative and managerial workers. The major groups 3, 4, 5, 6, and 7/8/9 were assumed to comprise "unskilled" workers; these groups include clerical and related workers; sales workers; service workers; agriculture, animal husbandry and forestry workers, fishermen and hunters; and production and related workers, transport and equipment operators and labourers.

Next, the number of workers involved in skilled and unskilled activities for every available country were calculated. Countries are then grouped by regions and industries in order to calculate the regional proportions of skilled and unskilled workers. These proportions are then used to split the wage bill (as taken from National Accounts) into remuneration to skilled and unskilled labour for each sector in each region.

Appendix 4.2: Calculation of average wage rates in each region

1. Homogeneous labour

In the homogeneous labour case, it is only necessary to calculate the average wage rate in each region. Given that there is no agreement as to how an average wage rate can be calculated, six possible measures were considered.

First, the wage bill for each region, as taken from National Accounts, was divided by total population (TOTP), as taken from the UN Demographic Yearbook (1996), Table 5. The population figures correspond to 1990 for every country, and these were then aggregated in order to obtain the population for each region (see Table A4.2.1).

Table A4.2.1: Regional Indicators

Region	TOTP [1/] (millions)	EAP [2/] (millions)	Wage Bill [3/] ($ millions)	GDP [4/] ($ millions)	AGDP [5/] ($ millions)
USA	249.9	126.9	3,313,600	5,066,300	5,066,300
JAP	123.5	63.6	1,611,804	3,734,955	4,108,451
EU	344.3	149.2	3,116,515	5,390,057	5,336,156
ODC	121.2	54.7	1,169,361	1,779,828	1,762,030
DAM	421.9	152.1	391,611	1,064,429	2,024,544
DAF	535.1	203.9	70,948	310,538	620,041
DAS	2,767.8	1,020.3	534,407	1,413,541	3,744,313
DE	466.6	217.8	817,351	1,318,958	1,978,437

[1/] TOTP corresponds to total population, as taken from the United Nations Demographic Yearbook (1996).
[2/] EAP corresponds to economically active population, as taken from several issues of the Yearbook of Labour Statistics (ILO).
[3/] The wage bill was taken from the benchmark data set (see Appendix 3.2).
[4/] GDP corresponds to GDP at factor costs, as taken from the benchmark data set (see Appendix 3.2).
[5/] AGDP corresponds to GDP at factor costs, adjusted using the exchange-rate deviation index by Kravis et. al. (1982).

Total population, however, exceeds the workforce in each region. Therefore, as a second measure of the average wage rate, the wage bill divided by the economically active population (EAP), as taken from the Yearbook of Labour Statistics, was used. Data on EAP for USA, JAP, and every country in EU and ODC were found. It was not possible to find information for every country in the remaining regions. In order to overcome this difficulty, I calculated the ratio of EAP to TOTP for each available country, and then averaged these ratios. The resulting ratios were then applied to the total population of the corresponding region.

In particular, for DAM I used data for Chile, Costa Rica, Ecuador, Honduras, Jamaica, Mexico, Panama, Paraguay, Trinidad and Tobago, Uruguay and Venezuela (36% of the total population corresponds to EAP). For DAF, I used data for Benin, Botswana, Burkina Faso, Burundi, Malawi, Mauritius, Nigeria, Rwanda, Seychelles and Swaziland (38.1% of the population corresponds to EAP). For DAS, I used data for Bahrain, Hong Kong, India, Iran, Jordan, Korea, Kuwait, Philippines, Sri Lanka and Thailand (36.9% of the population corresponds to EAP). Finally, for DE I used data for Bulgaria, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey, and Ukraine (46.7% of the population corresponds to EAP). The figures of economically active population used in the model are reported in Table A4.2.1.

The third and fourth measures use GDP per capita using TOTP and EAP, respectively. The figures of GDP correspond to GDP at factor costs for 1990, as taken from the benchmark data set (see Table A4.2.1).

Some authors (e.g. Kravis et. al. 1982), argue that there are some comparability problems when using GDP data, because of differences between official and purchasing power parity exchange rates. Therefore, as a fifth and sixth

measures of average wage rates, I use GDP per capita using TOTP and EAP, respectively, where the GDP has been adjusted by the exchange rate deviation index. This index is defined as "...the ratio of the real GDP per capita to the exchange-rate-converted GDP per capita" (Kravis et. al., 1982 p.11), and uses the U.S. as the numeraire country.

In particular, the following indexes for 1975 (the latest available year), as taken from Kravis et. al. (1982), were used: for JAP the index is 1.1; for the EU and ODC the index calculated for Europe, which is 0.99, was used; for DAM the index is 1.9, and corresponds to the average of the indices of Brazil (1.58), Colombia (2.83), Jamaica (1.23), Mexico(1.7), and Uruguay (2.17); for DAF the index is 2, and corresponds to the average of the indices of Kenya (1.95), Malawi (2.55), and Zambia (1.49); for DAS the index is 2.65, and corresponds to the average of the indices of Iran (1.7), Syria (2.5), India (3.23), Korea (2.54), Malaysia (1.98), Pakistan (3.12), Philippines (2.51), Sri Lanka (3.65), and Thailand (2.65); lastly, for DE the index is 1.5, and corresponds to the average of the indices of Hungary (1.68), Poland (1.39), Romania (1.37) and Yugoslavia (1.56). The adjusted GDP data are presented in Table A.4.2.1.

The resulting wages rates are presented in Table A.4.2.2.

Table A.4.2.2: Average wage rates – Homogeneous labour
(1990 US$)

Wage measures	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP	13,259	13,047	9,052	9,647	928	133	193	1,752
WB / EAP	26,119	25,345	20,892	21,373	2,575	348	524	3,753
GDP_{pc} (TOTP)	20,272	30,233	15,656	14,684	2,523	580	511	2,827
GDP_{pc} (EAP)	39,934	58,730	36,134	32,531	7,000	1,523	1,385	6,056
$AGDP_{pc}$ (TOTP)	20,272	33,257	15,499	14,537	4,798	1,159	1,353	4,240
$AGDP_{pc}$ (EAP)	39,934	64,603	35,772	32,205	13,314	3,041	3,670	9,084

Source: Calculations from the author.

2. Heterogeneous labour

In the case where the labour market is segmented, the average wage rates of skilled and unskilled labour in each region are calculated. In practice such data are not available. To overcome this difficulty I calculate the ratio of the average wage rate of skilled to unskilled labour for every region, χ^r. This ratio is then used to infer the average wage rates for skilled and unskilled labour in each region, such that the wage bill (W) in each region is equal to the remuneration of the two types of labour, i.e.:

$P^r_{Ls} Ls^r + P^r_{Lu} Lu^r = W^r$.

This equation has two unknowns, P^r_{Ls} and P^r_{Lu}, since L^r_{Ls} and L^r_{Lu} were calculated following the procedure stated in Appendix 4.1, and W^r can be obtained from National Accounts. This equation can be rewritten by multiplying the first term in the left hand side by $\left(P^r_{Lu}/P^r_{Lu}\right)$, resulting in:

$$P^r_{Lu} = \frac{W^r}{Lu^r + \chi^r Ls^r},$$

where χ^r is the ratio of the average wage rate of skilled to unskilled ratio, which is exogenously determined. Once P^r_{Lu} is calculated, the corresponding value for P^r_{Ls} is obtained.

For USA χ^r was calculated using data on median annual earnings of year-round full-time wage and salary workers by occupation for 1990 (Handbook of U.S. Labour Statistics, 1997). For skilled labour I use managerial and professional speciality. For unskilled labour the remaining categories were used: technical sales and administrative support; service occupations; precision production, craft and repair; operators, fabricators, and labourers; and farming, forestry and fishing. Next, I calculated a weighted average of the median annual earnings (weighted by the number of workers in each activity) for skilled and unskilled labour. The resulting ratio was 1.6425.

For the remaining regions, I use wages by economic activity taken from the Yearbook of Labour Statistics. Since one would expect that the remuneration of skilled labour is higher than that of unskilled labour, I use average earnings per worker in financing, insurance, real state and business services as proxy for skilled labour wages, while average earnings per worker in wholesale and retail trade, restaurants and hotels were used as proxy for unskilled labour wages.[16]

In the case of JAP, it was not possible to find the required data, so that I had to use the estimated value of χ^r for USA. For the EU, I used information for the United Kingdom (2.0304). For ODC, χ^r is equal to 1.3374, which corresponds to the average of the ratios for Canada, Finland, and Australia. For DAM, χ^r is equal to

[16]Average earnings include "...the remuneration in cash and in kind paid to employees, as a rule at regular intervals, for the time worked or work done together with remuneration for time not worked, such as for annual vacation, other paid leave or holidays" (ILO, 1996 p.665).

1.9568, which is the average of the ratios for Chile and Costa Rica. For DAF, χ^r is equal to 1.8155, which is the average of the ratios for Botswana and Egypt. For DAS, χ^r is equal to 1.4575, which is the average of the ratios for Korea, the Philippines and Thailand. Finally, for DE I used information for the Czech Republic (1.2546).

The resulting wages rates are presented in Table A.4.2.3.

Table A.4.2.3: Average wage rates – Heterogeneous labour
(1990 US$)

Wage Measures	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
WB / TOTP								
Unskilled labour	11,189	11,795	7,376	8,937	820	123	189	1,692
Skilled labour	18,378	19,373	14,976	11,952	1,604	222	271	2,122
WB / EAP								
Unskilled labour	22,041	22,912	17,023	19,798	2,274	322	512	3,624
Skilled labour	36,203	37,633	34,564	26,479	4,450	584	736	4,546
GDP_{pc} (TOTP)								
Unskilled labour	17,108	27,332	12,756	13,602	2,228	536	499	2,730
Skilled labour	28,100	44,892	25,901	18,192	4,359	974	718	3,425
GDP_{pc} (EAP)								
Unskilled labour	33,700	53,093	29,442	30,134	6,181	1,407	1,354	5,848
Skilled labour	55,352	87,206	59,779	40,302	12,094	2,555	1,947	7,336
$AGDP_{pc}$ (TOTP)								
Unskilled labour	17,108	30,065	12,629	13,466	4,237	1,071	1,322	4,094
Skilled labour	28,100	49,382	25,642	18,010	8,290	1,944	1,901	5,137
$AGDP_{pc}$ (EAP)								
Unskilled labour	33,700	58,402	29,147	29,832	11,756	2,810	3,587	8,771
Skilled labour	55,352	95,926	59,181	39,899	23,003	5,102	5,156	11,004

Source: Calculations from the author.

Appendix 4.3: Sensitivity analysis for labour-labour substitution elasticity ς

Table A4.3.1: Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by total population (WB / TOTP)									
Wage rate skilled labour	ς =0.50	-29	-33	-13	9	710	5,751	4,693	512
	ς =0.75	-40	-43	-26	-7	592	4,902	3,998	423
	ς =1.00	-45	-47	-32	-15.	536	4,494	3,663	381
	ς =1.50	-49	-52	-38	-22	482	4,108	3,347	340
	ς =1.75	-50	-53	-39	-24	468	4,003	3,261	329
	ς =2.50	-53	-55	-42	-27	443	3,824	3,115	311
Wage rate unskilled labour	ς =0.50	-64	-66	-45	-55	395	3,201	2,048	140
	ς =0.75	-62	-64	-42	-52	422	3,377	2,163	153
	ς =1.00	-61	-63	-41	-51	434	3,463	2,219	159
	ς =1.50	-60	-62	-39	-50	447	3,566	2,271	165
	ς =1.75	-60	-62	-39	-50	450	3,603	2,286	166
	ς =2.50	-59	-61	-38	-49	455	3,603	2,310	169
Return to capital	ς =0.50	80	82	70	97	307	910	795	209
	ς =0.75	80	83	71	97	310	917	806	207
	ς =1.00	81	84	72	98	311	921	812	207
	ς =1.50	81	85	72	98	312	924	817	206
	ς =1.75	81	85	72	98	312	925	818	206
	ς =2.50	81	85	72	98	313	926	820	206
Wage bill divided by the economically active population (WB / EAP)									
Wage rate skilled labour	ς =0.50	-20	-23	-16	9	549	4,843	3,823	535
	ς =0.75	-31	-33	-27	-5	464	4,195	3,308	452
	ς =1.00	-36	-38	-33	-12	422	3,881	3,059	411
	ς =1.50	-41	-43	-38	-19	383	3,583	2,822	373
	ς =1.75	-42	-44	-39	-21	373	3,501	2,758	363
	ς =2.50	-44	-46	-41	-24	355	3,364	2,648	345
Wage rate unskilled labour	ς =0.50	-56	-58	-43	-51	325	2,901	1,787	167
	ς =0.75	-54	-56	-40	-49	346	3,049	1,881	180
	ς =1.00	-53	-55	-39	-48	356	3,121	1,926	186
	ς =1.50	-52	-54	-38	-46	366	3,190	1,969	192
	ς =1.75	-52	-54	-37	-46	368	3,208	1,981	194
	ς =2.50	-51	-53	-37	-46	373	3,240	2,001	197

Table A4.3.1 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by the economically active population (WB / EAP)									
Return to capital	ς =0.50	66	67	58	82	255	809	699	217
	ς =0.75	67	68	59	83	258	817	710	216
	ς =1.00	67	69	60	83	259	822	715	216
	ς =1.50	67	70	60	83	261	825	720	216
	ς =1.75	67	70	60	83	261	827	722	216
	ς =2.50	67	70	60	84	262	828	724	216
GDP per capita using total population (GDP pc (TOTP))									
Wage rate skilled labour	ς =0.50	-14	-46	-6	33	455	2,383	3,268	606
	ς =0.75	-24	-52	-18	17	390	2,091	2,873	523
	ς =1.00	-29	-56	-23	10	358	1,950	2,681	483
	ς =1.50	-34	-58	-28	3	328	1,815	2,498	445
	ς =1.75	-35	-59	-29	1	320	1,779	2,448	434
	ς =2.50	-37	-61	-32	-3	306	1,717	2,365	417
Wage rate unskilled labour	ς =0.50	-49	-68	-32	-36	291	1,525	1,645	219
	ς =0.75	-47	-67	-29	-33	308	1,597	1,723	233
	ς =1.00	-46	-66	-27	-32	317	1,632	1,761	240
	ς =1.50	-45	-65	-26	-30	325	1,666	1,797	247
	ς =1.75	-44	-65	-25	-30	327	1,675	1,806	248
	ς =2.50	-44	-65	-25	-29	331	1,690	1,823	252
Return to capital	ς =0.50	56	51	52	77	227	452	630	246
	ς =0.75	56	53	53	78	229	458	641	246
	ς =1.00	56	54	53	78	231	461	646	247
	ς =1.50	56	54	54	78	232	464	651	247
	ς =1.75	56	55	54	78	233	464	652	247
	ς =2.50	56	55	54	78	233	465	654	247
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate skilled labour	ς =0.50	-7	-41	-14	27	324	1,905	2,531	598
	ς =0.75	-17	-47	-23	14	280	1,700	2,262	523
	ς =1.00	-22	-50	-27	8	259	1,600	2,130	492
	ς =1.50	-26	-53	-31	2	239	1,504	2,005	459
	ς =1.75	-27	-54	-33	0	233	1,478	1,971	450
	ς =2.50	-29	-55	-34	-3	224	1,435	1,914	435

Table A4.3.1 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate unskilled labour	ς =0.50	-41	-63	-32	-34	222	1,314	1,369	240
	ς =0.75	-39	-61	-30	-31	234	1,369	1,426	253
	ς =1.00	-38	-60	-29	-30	240	1,396	1,454	260
	ς =1.50	-36	-60	-27	-29	246	1,421	1,481	266
	ς =1.75	-36	-59	-27	-29	248	1,428	1,488	268
	ς =2.50	-36	-59	-26	-28	251	1,440	1,500	271
Return to capital	ς =0.50	44	35	38	62	176	382	528	247
	ς =0.75	44	36	39	62	179	387	537	248
	ς =1.00	44	37	40	62	180	390	541	249
	ς =1.50	44	38	40	63	181	392	545	249
	ς =1.75	44	38	40	63	181	393	547	249
	ς =2.50	45	38	41	63	182	394	548	250
Adjusted GDP per capita using total population (AGDP pc (TOTP))									
Wage rate skilled labour	ς =0.50	-7	-47	2	45	224	1,240	1,270	407
	ς =0.75	-13	-51	-5	35	193	1,151	1,179	373
	ς =1.00	-16	-52	-8	30	183	1,108	1,135	357
	ς =1.50	-19	-54	-12	26	173	1,066	1,092	341
	ς =1.75	-20	-55	-12	25	171	1,055	1,081	337
	ς =2.50	-21	-55	-14	23	167	1,038	1,063	330
Wage rate unskilled labour	ς =0.50	-30	-60	-6	-12	181	1,012	801	191
	ς =0.75	-29	-59	-3	-9	188	1,039	823	198
	ς =1.00	-28	-59	-2	-8	191	1,052	834	201
	ς =1.50	-27	-59	-1	-7	194	1,064	844	205
	ς =1.75	-27	-58	-1	-7	195	1,068	846	206
	ς =2.50	-27	-58	-0	-7	197	1,074	851	207
Return to capital	ς =0.50	20	1	33	43	134	285	322	189
	ς =0.75	20	2	34	43	136	288	326	190
	ς =1.00	20	2	34	43	137	289	328	191
	ς =1.50	20	3	35	43	138	291	330	191
	ς =1.75	20	3	35	43	138	291	331	192
	ς =2.50	20	3	35	43	138	291	331	192

Table A4.3.1 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Adjusted GDP per capita using the economically active population (AGDP pc (EAP))									
Wage rate skilled labour	ς=0.50	-4	-45	-10	33	131	949	930	383
	ς=0.75	-9	-48	-15	26	118	884	874	356
	ς=1.00	-12	-49	-17	22	112	857	847	344
	ς=1.50	-14	-51	-20	20	106	831	821	337
	ς=1.75	-15	-51	-20	18	105	824	814	328
	ς=2.50	-16	-51	-21	17	103	813	804	323
Wage rate unskilled labour	ς=0.50	-24	-56	-12	-14	119	816	618	194
	ς=0.75	-22	-55	-10	-12	123	834	632	199
	ς=1.00	-21	-55	-9	-11	125	843	639	202
	ς=1.50	-21	-54	-8	-10	127	851	645	205
	ς=1.75	-21	-54	-8	-10	128	853	647	205
	ς=2.50	-20	-54	-8	-10	129	857	650	207
Return to capital	ς=0.50	14	-8	20	30	91	224	250	180
	ς=0.75	14	-7	20	30	92	227	253	181
	ς=1.00	14	-7	20	30	93	228	254	181
	ς=1.50	14	-7	21	31	94	229	255	182
	ς=1.75	14	-7	21	31	94	229	255	182
	ς=2.50	14	-6	21	31	94	229	256	182

Table A4.3.2: Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by total population (WB / TOTP)									
Wage rate skilled labour	ς=0.50	-78	-80	-74	-67	147	1,685	1,362	87
	ς=0.75	-70	-72	-63	-54	244	2,284	1,935	160
	ς=1.00	-63	-65	-55	-44	318	2,922	2,376	216
	ς=1.50	-55	-57	-45	-31	415	3,622	2,949	289
	ς=1.75	-52	-55	-41	-26	448	3,857	3,142	314
	ς=2.50	-47	-49	-34	-18	512	4,319	3,520	362
Wage rate unskilled labour	ς=0.50	19	36	29	23	28	48	55	40
	ς=0.75	9	35	29	21	63	132	120	74
	ς=1.00	2	28	26	19	96	207	175	105
	ς=1.50	-7	13	18	16	149	311	248	152
	ς=1.75	-10	7	15	15	170	344	271	170
	ς=2.50	-16	-5	7	13	218	401	309	210
Return to capital	ς=0.50	-1	21	14	10	35	84	84	43
	ς=0.75	2	28	22	18	66	133	133	77
	ς=1.00	4	29	26	23	93	172	171	106
	ς=1.50	8	27	29	30	132	223	218	147
	ς=1.75	10	26	29	32	147	240	233	162
	ς=2.50	13	22	30	36	178	270	260	193
Wage bill divided by the economically active population (WB / EAP)									
Wage rate skilled labour	ς=0.50	-71	-72	-70	-61	133	1,679	1,311	128
	ς=0.75	-63	-64	-61	-49	205	2,224	1,744	199
	ς=1.00	-56	-58	-54	-40	257	2,620	2,058	249
	ς=1.50	-48	-50	-46	-29	323	3,120	2,455	314
	ς=1.75	-45	-47	-43	-25	344	3,285	2,586	335
	ς=2.50	-40	-42	-37	-18	387	3,610	2,843	377
Wage rate unskilled labour	ς=0.50	16	32	28	22	27	48	54	46
	ς=0.75	8	30	26	19	55	122	109	80
	ς=1.00	2	24	21	16	81	185	154	108
	ς=1.50	-6	12	12	13	121	268	212	150
	ς=1.75	-8	7	8	11	137	294	229	167
	ς=2.50	-13	-3	0	9	172	337	258	202

Table A4.3.2 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by the economically active population (WB / EAP)									
Return to capital	ς=0.50	-1	20	14	10	33	84	82	52
	ς=0.75	1	25	19	16	58	124	121	84
	ς=1.00	4	25	21	20	78	154	150	109
	ς=1.50	6	23	21	24	107	191	185	145
	ς=1.75	7	21	21	26	118	203	196	157
	ς=2.50	9	18	20	28	141	225	216	185
GDP per capita using total population (GDP pc (TOTP))									
Wage rate skilled labour	ς=0.50	-64	-76	-61	-45	131	933	1,302	194
	ς=0.75	-56	-72	-52	-31	186	1,180	1,636	264
	ς=1.00	-50	-69	-45	-22	224	1,351	1,869	313
	ς=1.50	-42	-65	-39	-12	267	1,537	2,023	364
	ς=1.75	-40	-63	-36	-8	282	1,604	2,112	383
	ς=2.50	-35	-60	-31	-2	311	1,734	2,283	420
Wage rate unskilled labour	ς=0.50	14	34	25	20	28	29	54	56
	ς=0.75	7	27	24	20	52	74	102	91
	ς=1.00	1	16	20	19	73	110	140	121
	ς=1.50	-5	-5	11	17	103	154	170	158
	ς=1.75	-7	-12	8	17	115	169	183	174
	ς=2.50	-11	-25	2	17	144	193	203	210
Return to capital	ς=0.50	-0	20	14	12	34	53	81	65
	ς=0.75	2	20	18	18	54	76	113	97
	ς=1.00	3	17	19	22	71	93	136	122
	ς=1.50	5	8	20	26	93	113	162	157
	ς=1.75	5	5	20	28	102	119	169	169
	ς=2.50	7	-1	19	30	120	130	183	195
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate skilled labour	ς=0.50	-55	-72	-59	-39	104	866	1,167	236
	ς=0.75	-47	-67	-51	-28	141	1,042	1,399	298
	ς=1.00	-42	-63	-46	-20	166	1,160	1,553	339
	ς=1.50	-35	-59	-40	-11	196	1,300	1,737	388
	ς=1.75	-33	-58	-38	-8	205	1,345	1,796	403
	ς=2.50	-29	-55	-35	-3	224	1,432	1,910	433

Table A4.3.2 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate unskilled labour	ς =0.50	11	28	23	18	25	26	48	61
	ς =0.75	5	20	19	17	42	64	88	94
	ς =1.00	1	10	14	16	57	93	117	120
	ς =1.50	-4	-6	6	14	80	131	153	159
	ς =1.75	-6	-11	3	14	89	143	163	173
	ς =2.50	-9	-22	-4	13	110	162	179	205
Return to capital	ς =0.50	-0	16	12	11	29	49	73	72
	ς =0.75	1	15	14	15	44	67	98	101
	ς =1.00	2	11	14	18	56	78	114	123
	ς =1.50	4	4	12	20	72	92	133	152
	ς =1.75	4	1	11	21	78	97	138	162
	ς =2.50	5	-4	10	23	90	104	147	185
Adjusted GDP per capita using total population (AGDP pc (TOTP))									
Wage rate skilled labour	ς =0.50	-41	-66	-35	-8	100	755	774	223
	ς =0.75	-35	-63	-29	1	120	836	857	254
	ς =1.00	-32	-61	-25	7	132	888	910	274
	ς =1.50	-27	-59	-21	13	146	949	972	297
	ς =1.75	-26	-58	-19	15	150	968	992	304
	ς =2.50	-23	-56	-15	21	162	1,019	1,044	324
Wage rate unskilled labour	ς =0.50	6	15	17	14	22	21	31	54
	ς =0.75	2	7	16	15	34	50	56	79
	ς =1.00	-1	-2	14	17	45	72	73	98
	ς =1.50	-5	-16	10	19	60	100	94	125
	ς =1.75	-7	-20	8	20	67	109	100	135
	ς =2.50	-9	-27	6	24	83	126	113	162
Return to capital	ς =0.50	-1	6	11	11	26	42	50	65
	ς =0.75	-1	3	12	15	36	53	62	85
	ς =1.00	-1	-2	13	17	43	61	71	99
	ς =1.50	-0	-9	13	20	54	70	80	119
	ς =1.75	-0	-11	13	21	57	73	83	127
	ς =2.50	-0	-12	14	25	68	80	91	145

Table A4.3.2 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Adjusted GDP per capita using the economically active population (AGDP pc (EAP))									
Wage rate skilled labour	ς =0.50	-32	-61	-36	-6	64	634	630	242
	ς =0.75	-27	-58	-32	1	75	689	680	266
	ς =1.00	-24	-56	-29	5	82	720	711	280
	ς =1.50	-21	-54	-26	9	90	756	747	297
	ς =1.75	-20	-54	-25	11	92	767	758	302
	ς =2.50	-18	-53	-23	14	97	789	780	312
Wage rate unskilled labour	ς =0.50	5	10	13	11	16	15	24	54
	ς =0.75	1	2	10	12	24	39	43	76
	ς =1.00	-1	-6	7	12	31	57	57	93
	ς =1.50	-4	-17	2	14	41	79	73	117
	ς =1.75	-5	-21	0	14	44	86	78	126
	ς =2.50	-7	-29	-4	16	53	97	86	147
Return to capital	ς =0.50	-1	2	7	9	19	34	40	65
	ς =0.75	-1	-2	7	11	25	42	49	82
	ς =1.00	-1	-6	7	13	30	47	55	95
	ς =1.50	-0	-12	5	14	36	53	62	111
	ς =1.75	-0	-14	5	15	39	55	63	118
	ς =2.50	-0	-18	3	16	44	58	67	131

Appendix 4.4: Sensitivity analysis for elasticity of substitution in production σ

Table A4.4.1: Distributional impacts of the removal of immigration controls
Homogeneous labour
(% change in factor prices)

Wage measures:		Regions USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by total population (WB / TOTP)									
Wage rate	σ =0.50	-82	-82	-74	-76	157	1,690	1,133	36
	σ =0.75	-66	-60	-54	-57	350	3,037	2,062	138
	σ =1.00	-56	-56	-36	-41	522	4,242	2,892	230
	σ =1.25	-46	-46	-22	-27	665	5,235	3,577	305
	σ =1.50	-38	-37	-10	-16	782	6,052	4,139	367
Return to capital	σ =0.50	100	115	64	79	80	255	265	57
	σ =0.75	100	100	75	97	226	664	625	155
	σ =1.00	96	90	84	111	372	1,134	1,018	246
	σ =1.25	91	82	90	118	503	1,598	1,396	321
	σ =1.50	87	77	93	122	617	2,034	1,748	383
Wage bill divided by the economically active population (WB / EAP)									
Wage rate	σ =0.50	-75	-74	-68	-69	156	1,796	1,159	76
	σ =0.75	-60	-59	-50	-52	302	2,873	1,874	176
	σ =1.00	-49	-47	-36	-37	420	3,748	2,455	257
	σ =1.25	-40	-38	-24	-26	513	4,437	2,913	321
	σ =1.50	-32	-30	-15	-17	588	4,991	3,281	372
Return to capital	σ =0.50	88	101	66	78	85	275	277	81
	σ =0.75	84	85	68	88	201	627	580	174
	σ =1.00	79	76	69	93	307	999	885	253
	σ =1.25	75	69	70	96	397	1,351	1,166	317
	σ =1.50	71	65	70	96	473	1,675	1,423	369
GDP per capita using total population (GDP pc (TOTP))									
Wage rate	σ =0.50	-67	-78	-57	-54	167	1,061	1,218	138
	σ =0.75	-53	-68	-39	-35	281	1,556	1,780	240
	σ =1.00	-42	-61	-25	-20	366	1,926	2,200	315
	σ =1.25	-34	-56	-15	-9	430	2,207	2,518	373
	σ =1.50	-28	-52	-6	-0	481	2,428	2,769	419
Return to capital	σ =0.50	78	122	59	74	94	176	292	115
	σ =0.75	71	80	60	82	189	369	547	209
	σ =1.00	65	55	61	87	270	557	789	284
	σ =1.25	61	40	62	90	335	726	1,005	343
	σ =1.50	57	30	63	91	389	879	1,198	390

Table A4.4.1 (Continued): Distributional impacts of the removal of immigration controls
Homogeneous labour
(% change in factor prices)

Wage measures:		Regions USA	JAP	EU	ODC	DAM	DAF	DAS	DE
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate	σ =0.50	-57	-70	-52	-47	148	1,039	1,153	149
	σ =0.75	-43	-61	-37	-30	224	1,388	1,537	226
	σ =1.00	-34	-55	-27	-19	277	1,632	1,806	279
	σ =1.25	-27	-50	-19	-10	316	1,813	2,003	319
	σ =1.50	-22	-47	-13	-4	347	1,952	2,157	349
Return to capital	σ =0.50	64	97	54	68	87	172	279	120
	σ =0.75	56	60	48	69	155	326	480	193
	σ =1.00	51	40	45	69	209	468	660	248
	σ =1.25	47	28	43	69	252	593	817	290
	σ =1.50	45	20	42	68	286	703	955	323
Adjusted GDP per capita using total population (AGDP pc (TOTP))									
Wage rate	σ =0.50	-40	-64	-22	-17	152	942	793	185
	σ =0.75	-32	-58	-11	-5	189	1,097	925	227
	σ =1.00	-26	-55	-3	3	213	1,195	1,009	254
	σ =1.25	-22	-53	2	9	229	1,263	1,067	273
	σ =1.50	-19	-51	6	13	242	1,315	1,112	287
Return to capital	σ =0.50	36	49	42	48	87	158	204	136
	σ =0.75	28	20	40	49	129	258	310	185
	σ =1.00	23	5	39	49	158	342	397	218
	σ =1.25	20	-4	38	49	180	414	469	242
	σ =1.50	18	-9	37	49	197	475	531	260
Adjusted GDP per capita using the economically active population (AGDP pc (EAP))									
Wage rate	σ =0.50	-31	-58	-23	-15	106	800	646	201
	σ =0.75	-24	-53	-16	-6	127	893	723	232
	σ =1.00	-20	-51	-11	-1	140	950	770	252
	σ =1.25	-17	-49	-7	3	149	990	803	265
	σ =1.50	-15	-47	-5	6	156	1,020	828	275
Return to capital	σ =0.50	27	30	32	38	65	132	168	137
	σ =0.75	20	8	27	37	91	208	246	180
	σ =1.00	17	-4	24	36	109	270	309	208
	σ =1.25	15	-10	22	35	122	322	360	227
	σ =1.50	13	-15	21	34	131	367	403	242

Table A4.4.2: Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by total population (WB / TOTP)									
Wage rate skilled labour	σ =0.50	-73	-74	-67	-58	212	2,158	1,749	136
	σ =0.75	-53	-56	-43	-28	434	3,759	3,061	304
	σ =1.00	-37	-40	-22	-2	627	5,152	4,203	449
	σ =1.25	-23	-27	-5	19	786	6,299	5,142	569
	σ =1.50	-11	-16	9	37	917	7,250	5,921	669
Wage rate unskilled labour	σ =0.50	-80	-81	-70	-75	172	1,711	1,078	32
	σ =0.75	-67	-69	-51	-59	344	2,862	1,828	115
	σ =1.00	-57	-59	-34	-46	489	3,829	2,457	186
	σ =1.25	-48	-51	-22	-35	605	4,603	2,960	242
	σ =1.50	-41	-44	-11	-27	700	5,231	3,370	288
Return to capital	σ =0.50	94	114	63	79	91	270	273	68
	σ =0.75	92	92	71	93	230	653	597	158
	σ =1.00	87	78	78	102	362	1,072	934	236
	σ =1.25	83	68	82	106	476	1,476	1,252	299
	σ =1.50	79	62	85	108	575	1,852	1,544	350
Wage bill divided by the economically active population (WB / EAP)									
Wage rate skilled labour	σ =0.50	-64	-65	-62	-50	197	2,160	1,694	190
	σ =0.75	-44	-46	-41	-24	355	3,367	2,651	345
	σ =1.00	-29	-31	-25	-2	482	4,331	3,446	469
	σ =1.25	-16	-19	-12	15	582	5,093	4,021	567
	σ =1.50	-6	-10	-2	28	663	5,713	4,513	647
Wage rate unskilled labour	σ =0.50	-73	-74	-64	-69	166	1,780	1,083	67
	σ =0.75	-59	-61	-47	-55	2293	2,677	1,646	147
	σ =1.00	-49	-51	-34	-44	391	3,368	2,081	208
	σ =1.25	-42	-44	-24	-35	466	3,899	2,445	255
	σ =1.50	-35	-38	-16	-28	526	4,322	2,681	293
Return to capital	σ =0.50	81	97	63	77	92	282	277	90
	σ =0.75	76	77	62	82	200	605	545	173
	σ =1.00	71	64	62	84	294	933	804	240
	σ =1.25	67	56	63	84	372	1,237	1,039	293
	σ =1.50	64	51	63	83	438	1,515	1,252	335

Table A4.4.2 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
GDP per capita using total population (GDP pc (TOTP))									
Wage rate skilled labour	σ =0.50	-55	-72	-51	-30	193	1,213	1,682	273
	σ =0.75	-36	-60	-31	-2	311	1,738	2,393	423
	σ =1.00	-23	-52	-16	19	398	2,127	2,921	533
	σ =1.25	-13	-45	-5	35	464	2,424	3,324	618
	σ =1.50	-4	-40	4	48	517	2,661	3,646	685
Wage rate unskilled labour	σ =0.50	-64	-78	-52	-55	173	1,035	1,120	123
	σ =0.75	-52	-70	-35	-39	270	1,438	1,552	202
	σ =1.00	-43	-64	-23	-28	339	1,726	1,862	259
	σ =1.25	-36	-60	-14	-20	391	1,940	2,091	300
	σ =1.50	-31	-57	-7	-13	431	2,106	2,270	333
Return to capital	σ =0.50	71	115	56	72	98	176	285	121
	σ =0.75	64	69	55	76	184	350	507	204
	σ =1.00	58	43	55	79	255	513	711	267
	σ =1.25	54	28	55	80	311	659	890	315
	σ =1.50	51	19	56	80	357	790	1,050	354
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate skilled labour	σ =0.50	-44	-65	-48	-23	1,108	1,108	1,485	321
	σ =0.75	-28	-54	-33	-1	1,463	1,463	1,951	444
	σ =1.00	-16	-47	-23	15	283	1,712	2,278	531
	σ =1.25	-8	-41	-15	27	322	1,898	2,522	596
	σ =1.50	-1	-37	-8	36	353	2,045	2,714	647
Wage rate unskilled labour	σ =0.50	-55	-71	-48	-49	147	983	1,026	161
	σ =0.75	-43	-64	-35	-36	210	1,263	1,317	228
	σ =1.00	-35	-47	-23	-28	253	1,453	1,513	274
	σ =1.25	-29	-55	-19	-21	285	1,590	1,656	307
	σ =1.50	-25	-52	-14	-16	309	1,696	1,766	332
Return to capital	σ =0.50	58	87	50	65	87	166	263	138
	σ =0.75	50	49	44	63	148	304	436	211
	σ =1.00	46	29	40	62	195	427	587	265
	σ =1.25	42	17	38	61	231	535	717	305
	σ =1.50	40	10	37	59	260	629	831	336

Table A4.4.2 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour - Both Ls and Lu migrate
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Adjusted GDP per capita using total population (AGDP pc (TOTP))									
Wage rate skilled labour	σ =0.50	-30	-60	-23	10	138	915	938	284
	σ =0.75	-20	-54	-12	25	171	1,057	1,083	338
	σ =1.00	-14	-51	-5	35	193	1,148	1,176	373
	σ =1.25	-9	-48	-0	42	208	1,213	1,242	397
	σ =1.50	-6	-46	3	47	219	1,262	1,293	415
Wage rate unskilled labour	σ =0.50	-39	-65	-17	-22	148	879	693	156
	σ =0.75	-31	-61	-7	-13	177	997	789	187
	σ =1.00	-27	-58	-1	-7	196	1,070	848	206
	σ =1.25	-24	-57	3	-3	208	1,120	888	219
	σ =1.50	-21	-55	7	-0	218	1,157	919	229
Return to capital	σ =0.50	31	40	38	45	83	148	186	130
	σ =0.75	24	12	36	44	119	236	275	171
	σ =1.00	20	-3	34	43	144	309	348	197
	σ =1.25	17	-11	34	43	162	370	408	216
	σ =1.50	15	-17	33	42	177	423	459	230
Adjusted GDP per capita using the economically active population (AGDP pc (EAP))									
Wage rate skilled labour	σ =0.50	-22	-55	-27	8	87	745	736	292
	σ =0.75	-14	-51	-20	19	106	828	818	330
	σ =1.00	-10	-48	-16	25	117	880	870	354
	σ =1.25	-6	-46	-12	30	126	917	906	371
	σ =1.50	-4	-44	-10	34	132	945	934	384
Wage rate unskilled labour	σ =0.50	-30	-60	-19	-21	101	741	559	169
	σ =0.75	-24	-56	-12	-14	118	810	613	192
	σ =1.00	-21	-54	-8	-10	127	852	646	205
	σ =1.25	-18	-53	-6	-8	134	880	668	214
	σ =1.50	-16	-52	-3	-6	139	901	685	221
Return to capital	σ =0.50	23	22	28	34	60	121	150	129
	σ =0.75	17	0	23	32	82	188	216	164
	σ =1.00	14	-11	20	30	97	242	268	187
	σ =1.25	12	-2	18	29	108	287	311	202
	σ =1.50	11	-21	17	28	116	326	347	214

Table A4.4.3: Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Wage bill divided by total population (WB / TOTP)									
Wage rate skilled labour	σ =0.50	-70	-71	-63	-54	245	2,395	1,944	161
	σ =0.75	-67	-69	-60	-50	276	2,618	2,126	184
	σ =1.00	-66	-67	-58	-47	293	2,737	2,224	197
	σ =1.25	-65	-67	-57	-46	303	2,811	2,284	205
	σ =1.50	-64	-66	-56	-45	310	2,862	2,327	210
Wage rate unskilled labour	σ =0.50	-10	14	11	5	74	207	153	77
	σ =0.75	0	26	22	15	80	191	156	88
	σ =1.00	6	32	28	20	83	177	155	94
	σ =1.25	9	36	32	24	85	168	155	98
	σ =1.50	11	39	35	26	86	161	154	101
Return to capital	σ =0.50	16	35	29	25	58	110	119	71
	σ =0.75	7	31	26	23	74	141	144	87
	σ =1.00	3	29	24	21	84	160	158	96
	σ =1.25	0	28	23	20	90	172	167	102
	σ =1.50	-1	27	23	19	95	181	174	106
Wage bill divided by the economically active population (WB / EAP)									
Wage rate skilled labour	σ =0.50	-63	-64	-61	-49	205	2,227	1,747	199
	σ =0.75	-60	-61	-58	-45	228	2,396	1,881	221
	σ =1.00	-58	-60	-56	-43	239	2,486	1,952	232
	σ =1.25	-57	-59	-55	-42	247	2,541	1,995	239
	σ =1.50	-57	-58	-55	-41	252	2,579	2,026	244
Wage rate unskilled labour	σ =0.50	-8	13	10	5	65	193	140	84
	σ =0.75	-0	22	19	13	69	174	140	93
	σ =1.00	4	28	24	18	71	160	138	98
	σ =1.25	7	31	27	20	72	151	137	101
	σ =1.50	9	33	29	22	73	144	136	103
Return to capital	σ =0.50	13	30	26	23	51	103	109	76
	σ =0.75	6	27	22	20	64	129	129	92
	σ =1.00	2	25	20	18	71	144	140	101
	σ =1.25	0	24	19	17	76	155	148	106
	σ =1.50	-1	23	18	16	80	162	154	110

Table A4.4.3 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions							
		USA	JAP	EU	ODC	DAM	DAF	DAS	DE
GDP per capita using total population (GDP pc (TOTP))									
Wage rate skilled labour	σ =0.50	-56	-72	-52	-32	186	1,179	1,635	264
	σ =0.75	-53	-71	-49	-28	203	1,254	1,737	285
	σ =1.00	-52	-70	-48	-25	211	1,294	1,790	296
	σ =1.25	-51	-69	-47	-24	217	1,318	1,823	303
	σ =1.50	-50	-69	-46	-23	220	1,334	1,846	308
Wage rate unskilled labour	σ =0.50	-7	8	10	10	61	116	131	99
	σ =0.75	0	16	18	16	64	104	129	106
	σ =1.00	4	21	22	20	65	95	126	110
	σ =1.25	6	23	24	22	66	90	124	112
	σ =1.50	7	25	26	23	66	85	123	114
Return to capital	σ =0.50	11	27	23	22	48	63	102	89
	σ =0.75	5	21	20	21	59	78	118	105
	σ =1.00	2	18	19	20	65	88	128	114
	σ =1.25	0	16	19	20	69	94	135	120
	σ =1.50	-1	15	18	19	72	98	139	124
GDP per capita using the economically active population (GDP pc (EAP))									
Wage rate skilled labour	σ =0.50	-47	-67	-51	-28	141	1,040	1,396	297
	σ =0.75	-45	-65	-49	-24	152	1,093	1,465	315
	σ =1.00	-44	-64	-48	-23	158	1,120	1,501	325
	σ =1.25	-43	-64	-47	-22	161	1,137	1,523	331
	σ =1.50	-42	-63	-47	-21	164	1,149	1,539	335
Wage rate unskilled labour	σ =0.50	-5	5	7	9	49	103	114	103
	σ =0.75	-0	11	13	14	51	90	110	108
	σ =1.00	3	15	17	16	52	82	107	111
	σ =1.25	5	17	18	18	52	76	105	112
	σ =1.50	6	18	20	19	52	72	103	114
Return to capital	σ =0.50	9	20	119	19	39	54	87	92
	σ =0.75	4	15	16	18	48	67	101	107
	σ =1.00	2	12	14	17	52	75	109	115
	σ =1.25	0	11	13	16	55	80	114	120
	σ =1.50	-1	10	12	16	57	84	117	124

Table A4.4.3 (Continued): Distributional impacts of the removal of immigration controls
Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Wage measures:		Regions USA	JAP	EU	ODC	DAM	DAF	DAS	DE
Adjusted GDP per capita using total population AGDP pc (TOTP))									
Wage rate skilled labour	σ =0.50	-35	-63	-29	1	119	835	856	254
	σ =0.75	-34	-62	-27	3	125	859	880	263
	σ =1.00	-33	-62	-26	5	128	871	893	267
	σ =1.25	-32	-61	-26	6	129	878	900	270
	σ =1.50	-32	-61	-25	6	131	883	905	272
Wage rate unskilled labour	σ =0.50	-5	-5	9	13	41	84	74	88
	σ =0.75	-2	-1	13	15	41	71	70	90
	σ =1.00	-0	2	15	17	41	63	67	91
	σ =1.25	1	3	16	17	40	58	65	91
	σ =1.50	2	4	16	18	40	54	63	92
Return to capital	σ =0.50	4	7	16	16	33	44	56	78
	σ =0.75	1	2	14	16	38	53	64	89
	σ =1.00	-1	-0	13	17	41	56	68	94
	σ =1.25	-2	-2	12	17	43	62	71	98
	σ =1.50	-3	-3	12	17	44	65	73	101
Adjusted GDP per capita using the economically active population (AGDPpc(EAP))									
Wage rate skilled labour	σ =0.50	-27	-58	-32	1	75	688	679	265
	σ =0.75	-26	-57	-31	3	78	702	694	272
	σ =1.00	-25	-57	-30	4	80	708	701	275
	σ =1.25	-25	-57	-30	4	81	714	706	277
	σ =1.50	-25	-57	-30	4	81	717	708	279
Wage rate unskilled labour	σ =0.50	-4	-7	4	10	28	69	59	85
	σ =0.75	-1	-4	7	11	28	57	54	86
	σ =1.00	-0	-3	8	12	28	50	52	86
	σ =1.25	0	-2	9	12	28	45	50	87
	σ =1.50	1	-1	10	13	28	42	49	87
Return to capital	σ =0.50	3	2	10	12	23	3	44	75
	σ =0.75	1	-2	8	12	26	42	49	85
	σ =1.00	-1	-4	7	12	28	46	53	90
	σ =1.25	-2	-6	6	12	30	49	55	94
	σ =1.50	-2	-6	6	12	30	51	58	96

Appendix 4.5: Distributional impacts of the removal of immigration controls in the presence of selective mobility

Table A4.5.1: Homogeneous labour
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DAM → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-23	-22	13	5	1,001	25	23	71
Return to capital	7	-10	23	15	575	25	24	71
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	-17	-48	-7	3	150	-8	-17	0
Return to capital	-16	-41	-6	-3	83	-8	-17	0
DAF → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-30	-29	2	-5	53	6,853	80	123
Return to capital	12	-10	53	28	53	1,606	84	123
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	422	223	483	547	576	676	531	604
Return to capital	442	288	531	531	576	198	533	604
DAS → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-51	-50	-28	-33	162	176	3,290	237
Return to capital	106	134	89	135	162	167	1,055	238
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	44	-11	60	78	132	144	1,464	197
Return to capital	72	73	103	125	132	140	578	197

Table A4.5.1 (Continued): Homogeneous labour
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DE → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-14	-12	26	17	66	62	47	553
Return to capital	7	-2	40	35	66	61	48	386
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	122	37	148	175	241	206	194	875
Return to capital	134	71	170	187	241	204	194	665
DAM → USA								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-34	81	109	79	844	91	74	135
Return to capital	5	81	109	79	510	90	76	135
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	-14	1	5	0	157	2	-1	11
Return to capital	-16	1	5	0	91	2	-1	11
DAS → JAP								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	-1	-97	1	-3	-5	-0	87	-1
Return to capital	-1	-68	1	-4	-5	-0	15	-1
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	-10	-91	-7	-10	-15	-8	67	-8
Return to capital	-8	-69	-7	-11	-15	-8	6	-8
DAF, DE → EU								
• Wage bill divided by total population (WB / TOTP)								
Wage rate	3	-16	-83	-26	-18	1,063	-18	-12
Return to capital	3	-16	-63	-26	-18	210	-17	-18
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate	-9	-23	-63	-27	-23	332	-24	45
Return to capital	-7	-23	-51	-27	-23	48	-24	22

Table A4.5.2: Heterogeneous labour – Both Ls and Lu migrate
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DAM → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	30	23	59	100	1,388	92	88	164
Wage rate unskilled labour	22	16	85	53	1,562	93	89	164
Return to capital	42	37	93	78	901	93	89	164
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	-15	-51	-21	18	104	-7	-17	0
Wage rate unskilled labour	-15	-51	-1	-3	145	-7	-16	0
Return to capital	-14	-42	-5	-4	76	-7	-17	0
DAF → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	91	81	134	193	254	15,674	319	426
Wage rate unskilled labour	74	65	164	118	254	15,705	323	425
Return to capital	131	112	268	207	254	3,796	332	424
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	52	13	42	110	65	1,013	59	85
Wage rate unskilled labour	43	-18	65	61	65	1,057	60	85
Return to capital	48	-0	70	70	65	265	60	85
DAS → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	88	79	131	189	542	575	12,661	743
Wage rate unskilled labour	29	22	95	61	542	579	7,509	731
Return to capital	404	462	369	484	542	561	2,749	737
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	23	-29	15	71	75	84	1,223	124
Wage rate unskilled labour	14	-34	32	29	75	85	975	122
Return to capital	32	27	57	27	75	82	387	122

Table A4.5.2 (Continued): Heterogeneous labour – Both Ls and Lu migrate
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DE → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	-15	-20	4	30	54	57	39	634
Wage rate unskilled labour	-10	-15	36	12	54	58	40	492
Return to capital	-6	-6	39	32	55	57	40	361
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	24	-28	17	73	81	82	62	525
Wage rate unskilled labour	28	-27	47	44	82	82	63	387
Return to capital	40	-2	65	70	82	81	63	345
DAM → USA								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	-57	15	30	13	393	20	10	45
Wage rate unskilled labour	-58	15	30	14	474	20	10	45
Return to capital	-6	15	30	14	265	20	11	45
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	-10	9	14	8	116	10	7	19
Wage rate unskilled labour	-6	9	14	8	170	10	7	19
Return to capital	7	9	14	8	96	10	7	19
DAS → JAP								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	88	-93	113	104	111	110	415	111
Wage rate unskilled labour	76	-94	112	104	111	110	292	111
Return to capital	80	-30	112	104	110	109	148	111
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	-5	-88	1	-3	-6	0	122	1
Wage rate unskilled labour	-4	-89	1	-3	-6	0	77	1
Return to capital	-4	-66	1	-3	-6	0	16	1

Table A4.5.2 (Continued): Heterogeneous labour – Both Ls and Lu migrate
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DAF, DE → EU								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	-8	-22	-84	-31	-26	974	-25	12
Wage rate unskilled labour	-3	-22	-82	-31	-26	962	-24	-23
Return to capital	-3	-22	-64	-31	-26	184	-24	-23
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	-10	-18	-63	-23	-17	330	-19	99
Wage rate unskilled labour	-6	-18	-57	-23	-17	348	-18	43
Return to capital	-5	-18	-46	-23	-17	55	-18	29

Note: → indicates the direction of the migration flow.

Table A4.5.3: Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DAM → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	41	34	72	117	1,518	102	102	124
Wage rate unskilled labour	79	78	100	105	398	102	102	124
Return to capital	80	78	99	104	393	101	102	125
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	27	-27	18	76	205	29	27	34
Wage rate unskilled labour	27	8	29	41	68	29	27	34
Return to capital	25	7	28	40	68	29	27	34
DAF → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	33	26	63	104	124	10,907	125	150
Wage rate unskilled labour	75	83	132	117	124	795	125	149
Return to capital	77	82	130	117	124	622	127	149
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	10	-36	3	53	18	1,097	14	20
Wage rate unskilled labour	9	-5	16	25	18	73	14	20
Return to capital	10	-5	16	24	18	66	14	20
DAS → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	7	2	32	66	228	230	7,200	283
Wage rate unskilled labour	138	253	208	203	228	231	610	283
Return to capital	140	248	202	208	228	227	615	282
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	70	-2	-59	136	123	116	1,723	134
Wage rate unskilled labour	85	97	109	123	123	116	209	133
Return to capital	87	95	107	123	123	115	211	133

Table A4.5.3 (Continued): Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DE → USA, JAP, EU, ODC								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	26	19	54	93	110	102	95	988
Wage rate unskilled labour	57	62	92	96	110	102	95	316
Return to capital	58	61	91	95	110	101	95	320
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	51	-13	41	109	95	84	80	657
Wage rate unskilled labour	59	43	75	88	95	84	80	228
Return to capital	61	42	74	87	96	84	80	237
DAM → USA								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	18	112	122	110	1,252	116	114	137
Wage rate unskilled labour	68	112	122	110	349	116	114	137
Return to capital	69	112	122	110	345	115	115	137
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	29	42	44	42	211	43	44	47
Wage rate unskilled labour	33	42	44	42	80	43	44	47
Return to capital	33	42	44	42	79	43	44	47
DAS → JAP								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	6	-94	12	9	8	11	358	13
Wage rate unskilled labour	5	-20	12	9	8	11	23	13
Return to capital	4	-22	12	9	8	11	23	13
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	84	-61	94	90	91	94	627	97
Wage rate unskilled labour	80	42	94	90	91	94	113	97
Return to capital	76	39	94	90	91	94	114	97

Table A4.5.3 (Continued): Heterogeneous labour – Only Ls migrates
(% change in factor prices)

Migration scenarios	Regions							
	USA	JAP	EU	ODC	DAM	DAF	DAS	DE
DAF, DE → EU								
• Wage bill divided by total population (WB / TOTP)								
Wage rate skilled labour	5	-2	-70	-6	-1	1,917	-1	111
Wage rate unskilled labour	4	-2	-20	-6	-1	91	-1	23
Return to capital	3	-2	-22	-6	-1	77	-1	25
• Adjusted GDP per capita using the economically active population (AGDP pc (EAP))								
Wage rate skilled labour	-2	-7	-51	-9	-5	465	-6	162
Wage rate unskilled labour	-2	-7	-20	-9	-5	12	-6	33
Return to capital	-2	-7	-21	-9	-5	9	-6	35

Note: → indicates the direction of the migration flow.

CHAPTER 5

CONCLUSIONS

In this thesis three policy issues that have become of particular relevance in the economic debate have been analysed using multiregional CGE models. First, the welfare effects of the decentralised provision of quasi-private goods by the government were quantified. Second, the issue of the exportation of domestic taxes from developed to developing countries was examined. And third, the efficiency gains from the elimination of global restrictions on international labour mobility were computed.

The multiregional CGE modelling literature distinguishes between two types of models. The first type disaggregates the national economy into regions, taking into consideration the linkages between different markets and different sectors of the economy. The second type of multiregional models focuses on the interrelationships among countries or groups of countries. In this thesis I used both a subnational and a supranational approach to regional modelling.

Chapter 2 presented numerical results on the welfare effects of the decentralised provision of health and education in Colombia. That is, to what extent will the Colombian population be better off when these goods are delivered locally as against centrally. A multiregional CGE model for Colombia was used to compare two provision scenarios: one in which the provision of health and education is carried out by the central government, against one in which provision is carried out by regional governments. In this modelling exercise, a provision rule based on the

median voter was considered, since the literature on the provision of quasi-private goods by the public sector mainly focuses on the characteristics of possible provision rules. In the median voter framework, each consumer is allocated the quantity demanded by the individual with the "median demand" for the good being publicly provided. In the model, consumers pay a fraction of the cost of the publicly provided quasi-private goods, and the government finances the remaining part with income taxes, either national, regional or both.

The results indicate that the decentralised provision of health and education improves the welfare of the Colombian population. With regional provision, each consumer group is allocated an amount of the goods that is closer to its preferences. More important is the magnitude of the gains; they vary between 1.3% and 2.3% of GDP, a substantial magnitude especially when compared with the efficiency gains associated to the tax reforms of the early nineties.

It is worth mentioning that the benefits from decentralised provision are not equally distributed among the regions. When the provision is financed by a national tax, regional provision leads to welfare losses in the Pacific, Atlantic and A&O regions, since these regions are subsidising the provision of the Andean region, which is the largest and most industrialised region in the country. In this case, there is redistribution among regions. When the provision is financed by regional taxes or a combination of national and regional taxes, all regions benefit from decentralised provision, and there is redistribution both within regions and among regions.

Chapter 3 presented some numerical results on the possibility that developed regions export domestic taxes to developing regions, particularly to those regions with which they have close commercial ties. A multiregional CGE model was used; this model incorporated domestic taxation and import tariffs of eight regions, chosfen

to represent world trade. Two variants of the model were considered: one in which both labour and capital were assumed to be internationally immobile, and another in which capital was assumed to be internationally mobile.

The results of the model suggest that when factors of production are internationally immobile, import tariffs are more important than domestic taxes in their effects on both welfare and terms of trade. The results also suggest that there is no tax exporting of domestic taxes by USA and EU to developing regions. In the case of JAP, the results indicate that there is some degree of tax exporting, but the effects on both welfare and terms of trade appear small. Income taxes have a rather small impact on welfare and terms of trade. In addition, in some cases the replacement of domestic taxes and/or import tariff had a negative effect on welfare. This may occur because the adverse terms of trade effects are strong enough that the removal of distorting domestic taxes could lead to reductions in national welfare.

In the second variant of the model, when capital is assumed to be internationally mobile, the results supported the existence of tax exporting of capital taxes by USA and EU to some particular developing regions. In the case of labour and income taxes, the results indicated that there is tax exporting from JAP to developing regions, although the effects on both welfare and terms of trade were small. In this case, once again, import tariffs are more important than domestic taxes in their effects on both welfare and terms of trade.

The effects that differential factor tax rates might have on the results of the model were also examined. Stronger terms of trade effects and larger welfare gains (loses) were found, which suggests that intersectoral effects play a very important role for tax exporting. In particular, more taxes could be exported if a region taxes more heavily those industries that constitute their main exports, as appear to be the

case of capital taxes in JAP and EU. The results also indicated that domestic tax policies in developed regions do not affect all developing regions in the same way. Policies will have stronger effects on those regions with which there are close commercial ties; for example, USA will mainly affect DAM, JAP will mainly affect DAS, and EU will mainly affect DAF and to a lesser extent DE.

In the light of these results, there is the possibility that "tax exporting" of domestic taxes will become an important part in trade negotiations in the foreseeable future. Throughout the years, commercial policies have been at the centre of trade negotiations, so that at the moment tariff levels are low in developed countries. However, the results of the model suggest that the benefits associated to further reductions in tariff levels in developed countries could be dampened by higher domestic factor taxes in these countries, since they can be exported to developing countries.

Chapter 4 computed the world-wide efficiency gains from the elimination of global restrictions on international labour mobility. In the analysis, wages differ across regions because of the existence of barriers to labour mobility, and wage rates are equalised as a result of the elimination of restrictions to labour mobility rather than free trade. One of the key features of this modelling exercise is the introduction of a segmented labour market, as two types of labour are considered: skilled and unskilled. When labour is heterogeneous, I considered the cases where a) both skilled and unskilled labour migrate, and b) only skilled labour migrates.

The results indicated that the elimination of global restrictions on labour mobility generates world-wide efficiency gains that could be of considerable magnitude, ranging between 15% and 67% of world GDP. When only skilled labour migrates welfare gains are smaller, since skilled labour is a small proportion of the

labour force in developing regions; in this case, efficiency gains range from 3% to 11% of world GDP.

Migration leads to a process of factor reallocation in which there are winners and losers. In the source regions, labour becomes more scarce relative to capital, and capital owners lose. However, not all workers are better off. Emigration will benefit workers whose skills are substitute to those of migrant labour, whereas it will hurt those workers whose skills are complementary to those of migrant workers. On the other hand, in the destination regions labour becomes more abundant (less scarce) relative to capital, and capital owners benefit. Again, not all workers in the destination regions are worse off. Immigration will benefit those workers whose skills are complementary to those of the immigrant worker, whereas immigration will hurt those workers whose skills are substitute to those of immigrant workers.

Next, three extensions to the model were introduced: a) transportation costs, since migration is a costly process; b) capital mobility, because capital markets have become more international in scope; and c) selective labour mobility, because some countries have introduced immigration control policies that allow migration flows from some regions and not from others.

With the introduction of transaction costs wages fail to equalise across regions, migration flows reduce, and in consequence efficiency gains are smaller. With capital mobility the return to capital equalises across regions. The removal of restrictions to skilled labour mobility makes labour move out of the regions with low average wages, and capital moves out of the regions where it is abundant relative to labour. Global welfare improves compared with the scenario without capital mobility (as a result of a better resource allocation), and migrants benefit as well. Lastly, selective labour mobility improves aggregate welfare, and the magnitude of the gain

depends on the size of the region in terms of the labour endowment. As to the remuneration to the factors of production, the main conclusions remain unaltered: labour benefits in the source regions, and capital in the destination regions. With a segmented labour market, skilled labour benefits from migration relative to unskilled labour in the source regions.

The results have shown that the elimination of global restrictions on labour mobility generates considerable world-wide efficiency gains. Despite these gains, the liberalisation of world-wide migration is far from realistic because of social and political tensions. Developed countries are very reluctant to open their borders to free migration because they do not want to become the destination of immigration of unskilled labour from developing countries. In the short-run, international migration flows are regulated by means of border controls and work permits. In the long-run, countries ought to concentrate their efforts in the elimination of the incentives to migrate, which could be accomplished by reducing income disparities among regions.

REFERENCES

Armington, P.S. (1969). A theory of demand for products distinguished by place of production. *International Monetary Fund Staff Papers* 16, 159-76.

Arrow, K. (1971). A Utilitarian Approach to the Concept of Equality in Public Expenditure. *Quarterly Journal of Economics*, Vol. 85, 409-415.

Atkinson, A. and Stiglitz, J. (1980). *Lectures on Public Economics*. McGraw-Hill, London.

Balestrino, A. (1995). Public Provision of Private Goods and User Charges. *Recherches Economiques de Louvain*, Vol. 61, No. 4, 461-477.

Besley, T. (1991). Welfare Improving User Charges for Publicly Provided Private Goods. *Scandinavian Journal of Economics*, Vol. 93, No. 4, 495-510.

Besley, T. and Coate, S. (1991). Public Provision of Private Goods and the Redistribution of Income. *American Economic Review*, Vol. 81, No. 4, 979-984.

Bhagwati, J., Panagariya, A. and Srinivasan, T. (1998). *Lectures on International Trade*, second edition. The MIT press, Cambridge.

Bhagwati, J. and Srinivasan, T. (1983). *Lectures on International Trade*. The MIT press, Cambridge.

Bird, R. (1993). Threading the fiscal labyrinth: Some issues in fiscal federalism. *National Tax Journal*, Vol. 46, No. 2, 207-227.

Blomquist, S. and Christiansen, V. (1994). *Public Provision of Private Goods as a Redistributive Device in an Optimum Income Tax Model*. Working Paper 1994:26, Department of Economics, Uppsala University, Sweden.

Blomquist, S. and Christiansen, V. (1998). Topping up or opting out? The optimal design of public provision schemes. *International Economic Review*, Vol. 39, No. 2, 390-411.

Boadway, R. (1974). The welfare foundations of cost-benefit analysis. *Economic Journal*, Vol. 84, 926-39.

Boadway, R., and Bruce, N. (1984). *Welfare Economics*, Basil Blackwell, Oxford.

Boadway, R., Roberts, S., and Shah, A. (1994). *The reform of fiscal systems in developing and emerging market economies: A federalism perspective*. Policy Research Working Paper 1259. Policy Research Department, Public Economics Division. The World Bank, Washington.

Borjas, G., Freeman, R., and Katz, L. (1997). How much do immigration and trade affect labour market outcomes? *Brookings Papers on Economic Activity*, 1, 1-67.

Brown, D. (1987). Tariffs, the terms of trade and national product differentiation. *Journal of Policy Modelling*, Vol. 9, No. 3, 503-526.

Buckberg, E. and Thomas, A. (1996). Wage dispersion in the 1980s: Resurrecting the role of trade through the effects of durable employment changes. *International Monetary Fund Staff Papers*, Vol. 43, No. 2, 336-354.

Burfisher, M., Robinson, S. and Thierfelder, K. (1994). Wage changes in a U.S.-Mexico free trade area: Migration versus Stolper-Samuelson effectcs, 195-222. In J. Francois and C. Shiells (eds.), *Modelling Trade Policy: Applied General Equilibrium assessments of North American Free Trade*. Cambridge University Press, Cambridge.

Damus, S., Hobson, P. and Thirsk, W. (1991). Foreign tax credits, the supply of foreign capital, and tax exporting. *Journal of Public Economics*, Vol. 45, 29-46.

Davis, S. (1992). Cross-country patterns of change in relative wages. *NBER Macroeconomics Annual*, 239-292, MIT press.

De Janvry, A, Sadoulet, E., and Fargeix, A. (1991). *Adjustment and Equity in Ecuador*. OECD, France.

DANE (1995a). Cuentas Nacionales de Colombia: Definitivas 1987-1992. *Boletín de Estadística* 505, April.

DANE (1995b). *Cuentas Departamentales de Colombia*.

Departamento Nacional de Planeación (1981). *Finanzas intergubernamentales en Colombia*, Informe final de la misión de finanzas intergubernamentales, Bogotá.

Dixit, A. and Norman, V. (1980). *Theory of International Trade: A dual General Equilibrium Approach*. James Nisbet and Company Limited and Cambridge University Press, Cambridge.

Economic Commission for Latin America and the Caribbean - ECLAC (1997). *Statistical Yearbook for Latin America and the Caribbean*. 1996 Edition.

Epple, D. and Romano, R. (1996). Public provision of private goods. *Journal of Political Economy*, Vol. 104, No. 1, 57-84.

EUROSTAT (1994). *International Trade in services*. EUR-12 from 1982 to 1991.

Fainboim, I., Acosta, O., and Cadena, H. (1994). *El proceso reciente de descentralización fiscal en Colombia y sus perspectivas*. Mimeo, April.

Foley, D. (1970). Economic equilibrium with costly marketing. *Journal of Economic Theory*, Vol. 2, 276-291.

Francois, J. and Shiells, C. (1994). *Modelling Trade Policy. Applied General Equilibrium Assessment of the North American Free Trade*. Cambridge University Press, Cambridge.

Fullerton, D. and Gordon, R. (1983). A re-examination of tax distortions in general equilibrium models, 369-420. In M. Feldstein (ed.) *Behavioural Simulation Methods in Tax Policy Analysis*. The University of Chicago Press, Chicago.

Garay, L. (1994). *Descentralización, bonanza petrolera y estabilización. La economía Colombiana en los años noventa*. FESCOL, CEREC, Bogotá.

GAMS386 (1989). Washington: IBRD/World Bank.

Gasiorek, M., Smith, A. and Venables, A. (1992). 1992: Trade and welfare; A general equilibrium model. *CEPR Discussion Paper*, No. 672.

GATT (1996). *Trade Policy Review*, Czech Republic.

GATT (1996). *Trade Policy Review*, Morocco.

GATT (1995). *Trade Policy Review*, Slovak Republic.

GATT (1994). *Trade Policy Review*, Iceland.

GATT (1994). *Trade Policy Review*, Tunisia.

GATT (1993). *Trade Policy Review*, European Community.

GATT (1993). *Trade Policy Review*, Mexico.

GATT (1993). *Trade Policy Review*, South Africa.

GATT (1993). *Trade Policy Review*, The Philippines.

GATT (1992). *Trade Policy Review*, Argentina.

GATT (1992). *Trade Policy Review*, Austria.

GATT (1992). *Trade Policy Review*, Bangladesh.

GATT (1992). *Trade Policy Review*, Brazil.

GATT (1992). *Trade Policy Review*, Canada.

GATT (1992). *Trade Policy Review*, Egypt.

GATT (1992). *Trade Policy Review*, Finland.

GATT (1992). *Trade Policy Review*, Ghana.

GATT (1992). *Trade Policy Review*, Japan.

GATT (1992). *Trade Policy Review*, Poland.

GATT (1992). *Trade Policy Review*, Republic of Korea.

GATT (1992). *Trade Policy Review*, Romania.

GATT (1992). *Trade Policy Review*, United States.

GATT (1992). *Trade Policy Review*, Uruguay.

GATT (1991). *Trade Policy Review*, Hungary.

GATT (1991). *Trade Policy Review*, Indonesia.

GATT (1991). *Trade Policy Review*, Nigeria.

GATT (1991). *Trade Policy Review*, Norway.

GATT (1991). *Trade Policy Review*, Switzerland.

GATT (1991). *Trade Policy Review*, Thailand.

GATT (1990). *Trade Policy Review*, Colombia.

GATT (1990). *Trade Policy Review*, Sweden.

GATT (1989). *Trade Policy Review*, Australia.

Glickman, N. (1977). *Econometric Analysis of Regional Systems. Explorations in Model Building and Policy Analysis*. Studies in Urban Economics. Academic Press, New York.

Goulder, L., Shown, J. and Whalley, J. (1983). Domestic tax policy and the foreign sector: The importance of alternative foreign sector formulations to results from a general equilibrium tax analysis model, 333-367. In M. Feldstein (ed.) *Behavioural simulation methods in tax policy analysis*, The University of Chicago Press, Chicago.

Hamermesh, D. and Grant, J. (1979). Econometric studies of labour-labour substitution and their implications for policy. *Journal of Human Resources* 14, 518-542.

Hamermesh, D. (1993). *Labour Demand.* Princeton university press, Princeton, New Jersey.

Hamilton, B. and Whalley, J. (1984). Efficiency and distributional implications of global restrictions on labour mobility. Calculations and policy implications. *Journal of Development Economics* 14, 61-75.

Handbook of U.S. Labour Statistics: Employment, Earnings, Prices, Productivity and other U.S. Labour Data (1997). Bernan Press; Lanham, Md.

Hare, P. (1988). Economics of the Publicly Provided Private Goods and Services. In Paul G. Hare (ed.) *Surveys in Public Sector Economics.* Basil Blackwell, Oxford, 68-101.

Hill, J. and Méndez, J. (1984). The effects of commercial policy on international migration flows: The case of the United States and Mexico. *Journal of International Economics* 17, 41-53.

Hirte, G. (1998). Welfare effects of regional income taxes. Results of an interregional CGE analysis for Germany. *The Annals of Regional Science*, Vol. 32, No. 2, 201-219.

Houthakker, H. and Magee, S. (1969). Income and price elasticities in world trade. *The Review of Economics and Statistics*, Vol. 51, No. 2, 111-125.

Inman, R. (1978). Testing Political Economy's "as if" preposition: is the median income voter really decisive?. *Public Choice*, Vol. 33, 45-65.

International Bureau of Fiscal Documentation (1998). *Annual Report 1997-1998.* Amsterdam.

International Bureau of Fiscal Documentation (1997). *Annual Report 1995-1996*. Amsterdam.

International Bureau of Fiscal Documentation (1996). *Annual Report 1994-1995*. Amsterdam.

International Labour Office (1996). *Yearbook of Labour Statistics*. Geneva.

International Labour Office (1994). *Yearbook of Labour Statistics*. Geneva.

International Labour Office (1993). *Yearbook of Labour Statistics*. Geneva.

International Labour Office (1992). *Yearbook of Labour Statistics*. Geneva.

International Monetary Fund (1996). *Balance of Payments Yearbook*. Part 2. World and regional tables.

International Monetary Fund (1996). *Government Finance Statistics Yearbook*, Vol.20.

International Monetary Fund (1994). *International Financial Statistics* (various issues).

Jones, R., Whalley, J. and Wigle, R. (1985). Regional impacts of tariffs in Canada: Preliminary results from a small dimensional numerical general equilibrium model, 175-188. In J. Piggott and J. Whalley (eds.) *New Developments in Applied General Equilibrium Analysis*. Cambridge University Press, Cambridge.

Jones, R. and Whalley, J. (1988). Regional Effects of Taxes in Canada: An Applied General Equilibrium Approach. *Journal of Public Economics*, Vol. 37, 1-28.

Jones, R. and Whalley, J. (1989). A Canadian Regional General Equilibrium Model and Some Applications. *Journal of Urban Economics*, Vol. 25, 368-404.

Khan, M. (1974). Import and export demand in developing countries. *International Monetary Fund Staff Papers 21*, 678-693.

Kimbell, L. and Harrison, G. (1984). General equilibrium analysis of regional fiscal incidence, 275-313. In H. Scarf and J. Shoven (eds.) *Applied General Equilibrium Analysis*. Cambridge University Press, Cambridge.

King, B. (1985). What is a SAM? In G. Pyatt and J. Round (eds.) *Social Accounting Matrices: A Basis for Planning*. World Bank, Washington.

King, M. and Fullerton, D. (1984). *The Taxation of Income from Capital: A comparative study of the United States, the United Kingdom, Sweden, and West Germany*. The University of Chicago Press, Chicago.

Kosters, M. (1994). An overview of changing wage patterns in the labour market. In J. Bhagwati and M. Kosters (eds.) *Trade and Wages: Leveling Wages Down?* The American Enterprise Institute Press, Washington.

Kravis, I., Heston, A. and Summers, R. (1982). *World Product and Income. International Comparisons of Real Gross Product*. The Johns Hopkins University Press. Baltimore.

Kraybill. D., Johnson, T. and Orden, D.(1992). Macroeconomic imbalances: A Multiregional General Equilibrium Analysis. *American Journal of Agricultural Economics*, Vol.74, No.3, 726,736. August.

Kraybill, D. and Lugani, S. (1992). *Multiregional Computable General Equilibrium Models: An Introduction and Survey*, University of Georgia, Department of Agricultural and Applied Economics, Mimeo, April.

Krugman, P. and Obstfeld, M. (1994). *International Economics: Theory and policy*. Third edition, Harper Collins.

Lawrence, R. and Slaughter, M. (1993). International trade and American wages in the 1980s: Giant sucking sound of small hiccup? *Brookings Papers on Economic Activity: Microeconomics*, 2, 161-210.

Layard, R., Blanchard, O.; Dornbusch, R. and Krugman, P. (1992). *East-West Migration. The Alternatives*. The MIT press, Cambridge.

Layard, R. and Walters, A. (1978). *Microeconomic Theory*. McGraw-Hill, Maidenhead.

Levy, S. and van Wijnbergen, S. (1994). Labour markets, migration and welfare. Agriculture in the North-American free trade agreement. *Journal of Development Economics*. 43, 263-278.

Lockwood, B. (1998a). The assignment of powers in federal and unitary states. *Warwick Economics Research Papers* 511, February.

Lockwood, B. (1998b). Distributive politics and the benefits of decentralisation. *Warwick Economics Research Papers* 513, August.

Lora, E. and Herrera, A. (1994). *Tax incidence in Colombia: A general equilibrium analysis*. Fedesarrollo. Mimeo, April.

Lucas, Jr., R. (1995). Why doesn't capital flow from rich to poor countries? *American Economic Review*, Papers and Proceedings, Vol. 80, 92-96.

Maechler, A. and Roland-Holst, D. (1997). Labour market structure and conduct. In J. Francois and K. Reinert (eds.) *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press, Cambridge.

Mansur, A. and Whalley, J. (1984). Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration and Data, 69-127. In H.E. Scarf and J.B. Shoven (eds.) *Applied General Equilibrium Analysis*, Cambridge University Press, Cambridge.

Marquez, J. (1990). Bilateral trade elasticities. *The Review of Economics and Statistics*, Vol. 72, No. 1, 70-77.

McLure, C., Jr. (1969). The inter-regional incidence of general regional taxes. *Public Finance,* Vol. 24, 456-483.

McLure, C., Jr. (1995). Comment on "Fiscal federalism and decentralisation: A review of some efficiency and macroeconomic aspects". In *Annual World Bank Conference on Development Economics 1995*, 317-322. M. Bruno and B. Pleskovik (eds.), World Bank, Washington.

Morgan, W.; Mutti, J. and Partridge, M. (1989). A Regional General Equilibrium Model of the US: Tax effects on factor movements and regional production. *The Review of Economics and Statistics*, Vol. 71, No. 4, 626-635.

Morgan, W., Mutti, J. and Rickman, D. (1996). Tax exporting, regional economic growth, and welfare. *Journal of Urban Economics,* Vol. 39, 131-159.

Mueller, D. (1989). *Public Choice II.* A Revised Edition of Public Choice. Cambridge University Press.

Munro, A. (1991). The Optimal Public Provision of Private Goods. *Journal of Public Economics*, Vol. 44, 239-261.

Murphy, K. and Welch, F. (1992). The Structure of Wages. *Quarterly Journal of Economics*, Vol. 107, No. 1, 285-326.

Mutti, J. and Morgan, W. (1986). Intestate tax exportation within the United States: An appraisal of the literature. *International Regional Science Review,* Vol. 10, No. 2, 89-112.

Mutti, J., Morgan, W. and Partridge, M. (1989). The incidence of regional taxes in a general equilibrium framework. *Journal of Public Economics* 39, 83-107.

Nguyen, D. and Bhuyan, R. (1977). Elasticities of export and import demand in some South Asian countries: Some estimates. *Bangladesh Development Studies*, Vol. 5, No. 2, 133-52.

Nguyen, T. and Wigle, R. (1992). Trade liberalisation with imperfect competition: The large and the small of it. *European Economic Review*, Vol. 36, 17-35.

Nguyen, T. and Whalley, J. (1986). Equilibrium under price controls with endogenous transaction costs. *Journal of Economic Theory*, Vol. 39, 290-300.

Nijkamp, P., ed. (1986). *Handbook of Regional and Urban Economics*, Vol. 1, North Holland, Amsterdam.

Nijkamp, P.; Rietveld, P. and Snickars, F. (1986). Regional and Multiregional Economic Models: A Survey. In *Handbook of Regional and Urban Economics*, Vol. 1, 257-294, P.J. Nijkamp (ed.), North Holland, Amsterdam.

Oates, W.E. (1972). *Fiscal Federalism*. Harcourt Brace Jovanovich, Inc. New York.

Oates, W.E. (1991). *Studies in Fiscal Federalism*. Edward Elgar. Aldershot.

Oates, W.E. (1993). Fiscal decentralisation and economic development. *National Tax Journal*, Vol. 46, No. 2, 237-243.

Pissarides, C. (1997). Learning by trading and the returns to human capital in developing countries. *The World Bank Economic Review*, Vol. 11, No. 1, 17-32.

Pyatt, G. (1988). A SAM approach to modelling. *Journal of Policy Modelling*, Vol. 10, No. 3, 327-352.

Pyatt, G. and Round, J, eds. (1985). *Social Accounting Matrices: A Basis for Planning*. World Bank, Washington, D.C.

Robinson, S.; Burfisher, M.; Hinojosa-Ojeda, R. and Thierfelder, K. (1993). Agricultural policies in a U.S.-Mexico free trade area: A computable general equilibrium analysis. *Journal of Policy Modelling* 15, 673-701.

Round, J. (1986). Social Accounting for Regional Economic Systems. *London Papers in Regional Science*, Vol. 15, 90-106.

Round, J. (1988). Incorporating the International, Regional, and Spatial Dimension in a SAM: Some Methods and Applications. *London Papers in Regional Science*, Vol. 19, 24-45

Samuelson, P.A. (1948). International trade and the equalisation of factor prices, *The Economic Journal*, Vol. 58, 163-184.

Samuelson, P.A. (1949). International factor price equalisation once again, *The Economic Journal*, Vol. 59, 181-197.

Sen, A. (1997). *On Economic Inequality*. Clarendon Press, Oxford.

Shiells, C. and Reinert, K. (1993). Armington models and terms of trade effects: some econometric evidence for North America. *Canadian Journal of Economics*, Vol. 26, No. 2, 299-316.

Shoven, J. and Whalley, J. (1984). Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey, *Journal of Economic Literature*, Vol. 22, 1007-51.

Shoven, J. and Whalley, J. (1992). *Applying General Equilibrium*. Cambridge University Press, Cambridge.

Stern, R., Francis, J. and Schumacher, B. (1976). *Price Elasticities in International Trade*. Macmillan Press.

St-Hilaire, F. and Whalley, J. (1987). A microconsistent data set for Canada for use in regional general equilibrium analysis, *Review of Income and Wealth*, Vol. 33, 327-343.

Tanzi, V. (1995). Fiscal federalism and decentralisation: A review of some efficiency and macroeconomic aspects, 295-315. In *Annual World Bank Conference on Development Economics 1995*. M. Bruno and B. Pleskovik (eds.), World Bank, Washington.

UNCTAD (1995). *Handbook of international trade and development statistics.*

United Nations (1996). *Demographic Yearbook 1994*. New York.

United Nations (1996). *National Accounts Statistics: Main Aggregates and Detailed Tables.*

Urrutia, M. (1994). Colombia. In J. Williamson (ed.), *The Political Economy of Policy Reform*. Institute for International Economics, Washington.

Valderrama, F. and Gutetiérrez, J. (1996). Matriz de contabilidad social SAM 1992 y multiplicadores de contabilidad. *Revista de Planeación y Desarrollo*, Vol. 27, No.1, 251-304, January-March.

van de Klundert, T. and Nahuis, R. (1998). Economic development and trade in the world economy. *Economic Modelling*, Vol. 15, 287-305.

Weyerbrock, S. (1995). Can the European community absorb more immigrants? A general equilibrium analysis of the labour market and macroeconomic effects of east-west migration in Europe. *Journal of Policy Modelling* 17, 85-120.

Whalley, John (1980a). Discriminatory features of domestic factor tax systems in a goods mobile-factors immobile trade model: An empirical general equilibrium approach. *Journal of Political Economy*, Vol. 88, No. 6, 1177-1202.

Whalley, John (1980b). General equilibrium analysis of U.S-EEC-Japanese trade and trade distorting policies: A model and some findings. *Économie Appliquée*, Vol. 33, No. 1, 191-230.

Whalley, John (1984). The North-South debate and the terms of trade: An applied equilibrium approach. *The Review of Economics and Statistics*, Vol. 66, No. 2, 224-234.

Whalley, J. (1985). *Trade Liberalisation among major world trading areas*. MIT press. Cambridge, Massachusetts.

Wiesner, E. (1992). *Colombia: Descentralización y federalismo fiscal.* Presidencia de la República y Departamento Nacional de Planeación, Bogotá.

Wigle, R. (1992). Transportation costs in regional models of foreign trade: An application to Canada-U.S. trade. *Journal of Regional Science*, Vol. 32, No.2, 185-207.

Wildasin, D. (1987a). The demand for public goods in the presence of tax exporting. *National Tax Journal,* Vol. 40, No.4, 591- 601.

Wildasin, D. (1987b). Tax exporting and the marginal cost of public spending. *Economics Letters*, Vol. 24, 353-358.

Wood, A. (1995). How trade hurt unskilled workers. *Journal of Economic Perspectives*, Vol. 9, No. 3, 57-80.

Wood, A. (1997). Openness and wage inequality in developing countries: the Latin American challenge to East Asian conventional wisdom. *The World Bank Economic Review*, Vol. 11, No. 1, 33-67.

Woodland, A. (1982). *International Trade and Resource Allocation.* Advanced textbooks in Economics Vol. 19, North Holland, Amsterdam.

World Bank (1994). *Colombia: Poverty Assessment Report.*

World Bank (1995). *World Tables.* Johns Hopkins University Press, Baltimore.